Exploring Best Practices for Implementing Design Thinking Processes in K12 Education

By

Alison Crane

B.A. Southern Methodist University, 2003

B.S. University of Missouri - Kansas City, 2006

M.A. University of Missouri - Kansas City, 2007

Submitted to the graduate degree program in the Department of Educational Leadership and Policy Studies and the Graduate Faculty of the University of Kansas in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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Chairperson, Dr. Ronald Aust

_____

Dr. Young-Jin Lee

_____

Dr. John Rury

_____

Dr. Richard Branham

_____

Dr. Michael Eckersley

Date Defended: April 6, 2018

The Dissertation Committee for Alison Crane certifies that this is the approved version of the following dissertation:

Exploring Best Practices for Implementing Design Thinking Processes in K12 Education

_____Chairperson, Dr. Ronald Aust

Date approved: April 27, 2018

Abstract

Before the mobile revolution, the father of educational technology Seymour Papert declared, "[T]he computer's true power as an educational medium lies…in the ability to facilitate and extend children's awesome natural ability and drive to construct, hypothesize, explore, experiment, evaluate, draw conclusions -- in short to learn -- all by themselves" (Papert, 1999). And yet today in the age of ubiquitous technology and mobile devices, kids (and adults) are buried in the infinite, mindless scrolling of the screen, both at home and at school (Turkle, 2011). In contrast to the increasingly distracted world we live in, the practice of design thinking has shown in both professional and educational arenas that practicing the skills designers use on the job can help students develop skills such as collaboration, empathy, creativity, and problem-solving (Soleas, 2015), as well as help teachers create effective, interdisciplinary curricula to meet the demands of the 21st century future-ready, tech-driven classroom (*Design thinking for educators,* 2011). The action research study outlined here explores the implementation of design thinking across digital and physical interactions among educators. Using qualitative methods of inquiry and data collection, the research gathered here illustrates, at least in a small corner of the educational sphere, that teachers and students alike are passionate to learn as Papert described, but they have also become weary of the technology overload (Cuban, 2015). This study investigates how using the action research methodology of planning, acting, observing, and reflecting led to several iterations of implementing the design process, each time learning more about educators' perspectives on design and technology. The study concluded with a series of guiding principles and a recommendation for a framework to introduce educators to utilizing design thinking in the classroom.

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Acknowledgements

There are a number of individuals I would like to thank for their guidance throughout this process. First, I would like to sincerely thank my advisor, Dr. Ron Aust, without whose encouragement and genuine excitement about my research, this journey would have never been possible. I would also like to thank Dr. Richard Branham, Dr. Michael Eckersley, Dr. Young-Jin Lee, and Dr. John Rury for their guidance, support, and patience in my academic endeavors. Thank you all for your time in serving on my committee and offering your invaluable expertise. Also to Dr. Robert Isaacson, for the gentle reminders to just keep writing.

Thank you to my family, friends, and colleagues. To my mother, I could not have done this without you. To my father, for teaching me at a young age to learn for learning's sake. To my brother, for believing I was capable. To my colleagues, you have been amazingly flexible, positive, and inspiring, truly the best. To Mrs. Darnell, who saw before anyone else that I was destined to write. To Mrs. Hassig, my mentor, friend, and quite possibly the greatest educator I have ever known. A special thanks to my husband, Nick, for your unending patience, inspiration, and support along this road, my biggest cheerleader. And to Grace, your smile motivated me to finish.

CHAPTER 1

INTRODUCTION

What is Design Education?

Design education in the elementary and secondary schools is a contemporary topic in the United States, and it has become increasingly popular in recent years. While design is not a subject that is widely taught in United States K12 schools, some believe that learning design skills must be given the same emphasis as subjects such as science, literacy, and math skills (Archer, Baynes, & Roberts, 2005). Cross (2007) and Archer (2005) argue that Design as a subject is complementary to the sciences and humanities, that to design requires analysis of both the sciences and humanities, and that to study design is to study the artificial world, the world of technology, and of making and doing. In an educational application, the process of designing something requires that "students must have first internalized information (formed a cognitive framework, a schema), then they must transfer their knowledge, strategize, and then communicate their idea (expression)" (Soleas, 2015, p. 6). Additionally, to think like a designer is to not just think critically and creatively but also to explore all aspects of a problem, work effectively under constraints, collaborate with various types of personalities, and persist in trying many possible solutions until the best one is reached (Brown, 2008).

With the introduction of initiatives such as STEM/STEAM education, Common Core standards, NextGen Science Standards, Partnership for 21st Century Skills, and the XQ Super School Project, students across the United States are being asked to analyze and synthesize information from a variety of fields, using higher-order thinking to apply content knowledge in increasingly innovative, collaborative, and complex ways (Common Core Standards, 2010). Engaging in design thinking and processes could potentially give students the skills they need to be successful with challenging new standards and expectations from future employers. And if design

thinking can help students master these new standards and skills, could it also help educators develop innovative practices and deeper critical thinking?

All these qualities are necessary to be successful as learners and teachers, but they are not always skills that come naturally nor are they skills that are formally taught in the current educational and pre-service curricula. Rather, the current educational model is more linear, where students proceed through steps in a process to arrive at a correct answer. This method has been ideal for achieving results on standardized tests, but it has also hampered innovation and problem solving, both for students and teachers (Harlen & Deakin Crick, 2003). To think like a designer is not to think in linear steps, but to think in three spaces, inspiration, ideation, and implementation, cycling through phases of research, idea generation and testing and eventually evaluation (Brown, 2008). Rather than just completing a worksheet, passing an exam, or even creating a project, designers "need to consider such issues as the needs of the audience, the distribution of work in a group, the management of time and resources, and the deadline" (Hsiao & Liu, 2002, p. 311).

This type of work is called authentic learning, where students are exposed to real-world concepts and situations and are asked to apply knowledge from their school curriculum to an issue that relates to everyday life (Thomas, 2000). When students are given the opportunity to engage in design challenges, research has found that students have a "natural motivation for discussing the rationale behind their own design decisions" and want to hear how others developed their solutions (Kolodner et al., 2003, p. 505). One of the key mottos of IDEO, a world-recognized leader in the practice of design, is "Fail often in order to succeed sooner" (Zuber et al, 2005, p. 45). In a world that relies on new products and innovation, the high-stakes testing model is virtually both nonexistent and irrelevant. Students who are allowed to experience learning through design may find increased motivation to work towards eventual success, especially amid the increased challenges of these new educational initiatives and employment demands. According to research on learning in the 21st century, "In recent years, educators, business leaders, and policymakers in

the U.S. have questioned whether the current design of assessment systems focuses too much on measuring students' ability to recall discrete facts using multiple choice tests at the cost of not adequately measuring a student's ability to engage in and complete complex thinking and problem-solving tasks" (Wan, 2011, p. 56). Students who can relate their experiences to the real world and find success in design are not only likely to gain valuable academic skills but also to develop greater motivation, focus, and confidence amid struggle.

Why Design Learning?

John Dewey promoted the idea of using experiences that relate to students, expecting that teachers would do the hard work of providing those types of learning experiences (Dewey, 1938). However, as teachers are continually bogged down with increasing responsibilities inside and outside the classroom, it is difficult for them to find time to design and implement these engaging learning experiences. As 21st century skills such as collaboration, critical thinking, and problem solving as well as STEM/STEAM, NextGen Science Standards, and Common Core State Standards (CCSS) are parts of educational curriculum, teachers are being asked to do just this: create meaningful learning experiences for students that not only teach the basic curriculum but also promote higher-level thinking, inquiry, collaboration, and increased text complexity. Research shows that project and problem based learning can provide these types of rich learning experiences, and even teachers agree that they are effective, yet Willingham (2009) observes, "Teachers don't use them. Recent data show that most instructional time is composed of seatwork and whole-class instruction led by the teacher" (p. 19). Teachers need to be given access to meaningful, standards-aligned, easy-to-implement, incentivized resources to make the transition to educational reforms.

Countries around the world are beginning to create national education initiatives that incorporate design standards from kindergarten through university levels. In Great Britain, design has been a part of the national standards for several decades; the Coldstream Report of 1960,

developed by Chairman of the National Advisory Council on Art Education William Coldstream, is often cited as the taking-off point for art and design education reform in Great Britain. Design professor Bruce Archer began advocating for design education as its own subject in the 1960s and continued to be a supporter of design education throughout the last half-decade (Archer et al., 2005). As early as the 1960s, art and design standards became a part of the national curriculum, and design and technology standards were introduced in the late 1980s. As a result, Great Britain has become well-known for its design and creativity.

In a British report on design education around the world, it notes countries such as Finland and South Korea used national design policies to bring about huge economic recovery, seeing the global rise of companies like Nokia and Samsung. Less developed countries are also beginning to see design education as a way to increase economic growth; in the last decade, Singapore has adopted a national design curriculum intended to strengthen innovation and value in an increasingly knowledge- and experience-based economy ("Why design," 2013). The governments of Mexico, Colombia, and Denmark are also working with designers to create national design education initiatives that will help improve the lives of their citizens and their economies.

Within the United States, design has been a major focus of industry for several decades, although the bulk of design education occurs at the university and professional levels. Only recently have discussions started to incorporate design into the national art standards developed by the National Arts Educators Association. Around the country, schools, workshops, and conferences have begun to focus on design learning in K12 schools; however, these events and environments are not connected by any broad design movement in education. In California, the d.school of Stanford recently began developing materials for K12 teachers, and IDEO has been working with Riverdale School to create toolkits that instruct teachers how to use design thinking in the classroom. While these methods are starting to see groundswell, there is little opportunity for interested educators to share resources, classroom experiences, and work together to develop

connections with one another. Educators are beginning to understand the need for a larger community with which to engage and bring about innovative teaching practices, using the methods of design to both teach and learn.

Design Learning, Innovation, and Communities of Practice

Within the small community of K12 design education, educators are demonstrating how they use the design process to teach more effectively, bring about positive change within their school culture, and engage students in real-world learning (IDEO, 2011). Historically, widespread educational reform happens when a top-down structure is in place, whether it is district, state, or nationally mandated (Cuban, 1986). However, with the possibilities of networked technology, individuals can reach a much broader audience at a much quicker pace. As smaller groups of educators innovate within their communities, technology allows their learning and results to be broadcast globally. Brown and Duguid (1991) describe these "'maverick' communities" as a way of offering the larger network "a means and a model to examine the potential of alternative views of organizational activity through spontaneously occurring experiments that are simultaneously informed and checked by experience" (p. 11).

Communities that organize around a topic, and specifically a practice or profession, have become recognized for the type of knowledge sharing and creation that occurs within them. These communities of practice can be studied using tools of ethnography to observe how communities of individuals come together based on a shared interest and how they interact, share knowledge, create knowledge, and improve the practice of that group. Wenger (2011) described three necessary elements of a community of practice: a domain (the area of interest), a community (people who actively engage in activities or discussions), and a practice (they are active practitioners in their area of interest) (pp. 1-2). Design education in K12 curriculum is a contemporary topic, and the teacher groups that are embracing this subject are geographically disconnected; while the domain and practice are present, the community is lacking. Unlike other

educational organizations with national communities, such as the National Arts Education Association or the National Council of Teachers of Mathematics that incorporate national, state, and online communities of practice, design educators have no such existing community. However, leaders in this field are currently working together, both physically and virtually, to build effective and connected communities of practice.

Purpose of Study

Currently, with the exception of Wisconsin, design education is not included in any state or national curriculum standards, yet educators and designers alike believe this should be the case. A brief survey of university programs, national conference topics, LinkedIn groups, Facebook groups, and design-specific schools illustrate that while K12 design learning is an important topic, these instances tend to be disconnected. Unlike groups such as the National Association of Art Educators (NAEA), the National Council for the Teachers of Mathematics (NCTM), and the National Science Teachers Association (NSTA), there is no single network, organization, or community that educates teachers about how to develop, implement, and assess design learning for teachers and students. Because of this, teachers and designers across the country are heading to the web to connect with each other to bring design learning to their students and staff, effectively creating their own community of practice. Additionally, these educators and designers recognize the need to collaborate with one another, intuitively acknowledging that this type of learning cannot be gained without a context, a situation, or a community in which to learn from one another.

The purpose of this study is to examine the current landscape of design thinking in education and both its role in and impact on K12 educational innovation; observe how a burgeoning K12 design thinking-based community of practice develops, interacts, and supports innovation using a variety of physical and technological processes; and ultimately use the design process to research and engage the stakeholders involved, developing solutions that attempt to

address the problem of teaching educators how to effectively use the design process to solve problems in education. As design and education are both interdisciplinary fields, this research study will utilize interdisciplinary research methods from both education and design, incorporating action research methods to examine the totality of the topic at hand, while simultaneously engaging in the participatory design process to brainstorm ideas and methods of effective teacher training in the design process.

Research Questions

Using the work of former art educator Dr. Betty Garner (2007) as a framework for teaching and learning, the following research questions are related to five instructional steps: explore (problem area), describe (current state), explain (analysis of current state), demonstrate (apply knowledge), and evaluate (reflect and improve) (p. 148). In order to discover how teachers can effectively network across state and national lines to learn about and implement design learning in their classrooms, the following research questions will be addressed in this study:

1. What core guiding principles of design thinking are most important, relevant, and feasible in K12 education? (explore)
2. What are the best methods for K12 educators to learn and share knowledge about teaching design thinking? (describe, explain)
3. How might educators best prepare for implementing design thinking in the 21st century classroom? (demonstrate, evaluate)

Because this study will be applying an action research approach, which is a form of research that seeks to discover solutions to problems through active participation and iterative investigation cycles, researchers typically do not begin with hypotheses to the research questions (Stringer, 2007). Rather, the researcher will seek to frame the problem through a series of qualitative data collection, followed by quantitative methods when appropriate. While this study does not outline specific hypotheses, the intended outcome includes the development of an active

community of practice that provides teachers with the necessary resources and support system to implement design-based experiences across the K12 curriculum while adhering to 21st century skills, STEM/STEAM principles, and other content-based standards.

Significance of Study

The significance of this study is multifaceted in that it has the potential to connect key players in design and education in new and purposeful ways. First, educators will have the opportunity to join a newly formed community of practice and contribute to the body of knowledge in K12 design learning. Currently, bodies of educators work in isolated locations to introduce design learning into the classroom. This may include a few teachers in one district, a charter school in another city, or a district initiative in yet another distant area, with education specialists and professors trying to bring them all together. By observing effective design-based communities around the country, including how they interact, what technology tools they use for collaboration, and the impact of their process, the intended goal is that a standardized approach to teaching design thinking will lead to widespread use of the process and greater connectivity between educators across the United States and beyond. Willingham calls for greater teacher collaboration to accomplish the goals of new educational reforms, including 21st century skills, but he also asks, "Where will schools find the release time for such collaboration? Will they hire more teachers or increase class size? How will they provide the technology infrastructure that will enable teachers to collaborate with more than just the teacher down the hall? Who will build and maintain and edit the Web sites, wikis, and so forth?" (Rotherham & Willingham, 2009, p. 19). This study seeks to explore some of these questions, investigating how the design process could help address and propose possible solutions to both synchronous and asynchronous teacher collaboration.

Another benefit will be that having a professional community for K12 design learning will allow others to enter the conversation. Designers will have the opportunity to participate and offer

valuable feedback to educators about projects, lesson ideas, and collaborations between students and professionals. Educators in a variety of subject areas, especially STEM/STEAM subjects, will be able to utilize design thinking and learning in interdisciplinary ways. Additionally, policy makers will have documented artifacts with which to base educational policy, state and national standards, and establish connections between K12 design learning and performance in higher education, professional careers, and economic development.

Finally, the broader investigation of how innovation in education can be approached through communities of practice can contribute to the increasing body of knowledge on online, virtual, and blended communities. Research currently shows that online communities of practice have yet to consistently produce communities as successful as traditional ones in terms of knowledge sharing and creation, personal interaction, and sustained community (Zhang & Watts, 2008). By using the design process in the investigation of K12 design-based communities, this study can help determine the relevance and effectiveness of design methods in education as measured by innovation in the classroom, as well as among schools and districts.

Definition of Terms

Communities of practice: As articulated by Lave and Wenger (1991), communities of practice describe groups of individuals who form a community based on the sharing of knowledge about a craft or profession, and the experiences, personal development, and knowledge base that is created out of the interaction of that community.

Design education: While design education more frequently refers to the education of design as a specific subject or content area, design education also refers to a process of thinking that can be applied across the content areas: **"**Design problems frequently require the work of interdisciplinary teams of experts… [and] demonstrate to children the value of collective creativity. Through design activities, students learn about planning, collaborating, and building a common vision of success" (Davis, 1999, p. 11).

Design thinking: Design thinking is a term that refers to the cognitive processes and skills related to designing such as abductive reasoning, exploring multiple solutions, working within parameters, and evaluating the effectiveness of both form and function (Cross, 2007).

Design process: Though many models of the design process exist, this research will reference the process developed by IDEO, wherein designers move iteratively through the following stages: research (what is the problem? what are the needs?), define (determine the parameters of the problem), brainstorm (what are all the possible ways of solving the problem?), prototype (choose the best ideas, develop basic models and try them out with users), and reflect (collect user data, and revise if necessary) (IDEO, 2011). These stages are often both iterative and reflective, as designers continually redesign and retest ideas in order to fully meet the needs of their users.

21st century skills: As defined by the Partnership for 21st Century Learning, an organization made up of multiple industry and state-level education partners, the four 21st century skills include collaboration, communication, critical thinking, and creativity.

STEM/STEAM: The interdisciplinary study of science, technology, engineering, and mathematics; art and design have been championed by industry and education alike, pushing for the expansion of STEM to STEAM to incorporate greater focus on creativity.

CHAPTER 2

REVIEW OF LITERATURE

Learning in the 21st Century

As far back as the early 1970s, Donald Schon (1973) was describing the effects of continuous change and what he called the "loss of the stable state." To Schon, this meant "that our society and all of its institutions are in *continuous* processes of transformation. We cannot expect new stable states that will endure for our own lifetimes" (1973, pp. 28). To adapt to these continuous changes, Schon says, "We must. . . become adept at learning" (1973, p. 29). Regarding education, which is its own stable state, how do students, teachers, administrators, and policy-makers adjust to this ever-changing landscape of information and technology? Some would argue that "the old ways of learning are *unable to keep up* with our rapidly changing world" (Thomas & Brown, 2011, p. 50) and that new methods must be implemented to guide learners through the ever-expanding information age. Thomas and Brown (2011) suggest developing a new culture of learning in which "learning focuses on learning through engagement *within* the world," as opposed to the "teaching-based approach [which] focuses on teaching us *about* the world" (p. 50).

The question then becomes, how does a state or national level institution like education switch gears and begin to implement a new model of teaching and learning? Currently, the National Governors Association (NGA) and the Council of Chief State School Officers (CCSSO) have worked with several national organizations to create the CCSS that outline not only content-area standards for reading, writing, and math across the disciplines but also include standards for helping students adapt to these changes and learn how to identify and critique the vast amount of information available through technology and the Internet (NGA & CCSSO, 2010). One possible method for providing the necessary content for children in K12 schools while simultaneously teaching students the necessary skills for navigating the 21st century world is to incorporate design learning into the classroom. Engaging students through the design process allows them to rapidly

adapt to change, develop critical thinking skills, practice perseverance, and collaborate and communicate with a variety of personalities (Brown, 2008).

However, while districts across the country are working to train teachers to teach these new standards, little has been done to acknowledge that teachers are also a part of this quickly changing learning structure, and teachers need to learn these same problem-solving and critical thinking skills in order to adapt to changing pedagogies. What the education standards do not include are practical pedagogical methods for conveying these standards. In a CCSS-preparedness survey of K12 educators and administrators, almost two-thirds of respondents indicated they needed more time to plan as well as curricular resources aligned to CCSS ("Findings from a," 2013), suggesting that teachers do not feel prepared to teach the new standards. When teachers use the design process to create design-based lessons and collaborate with other educators, they begin to experience the same benefits of their students: effective communication and collaboration skills, perseverance through difficult challenges, problem solving skills, and adapting to change.

Design Thinking

While it is important to understand how design education can benefit student learning and why it should be part of the K12 curriculum, this research study seeks to investigate whether learning about, practicing, and teaching design thinking can help teachers solve problems in the areas of ensuring content mastery for students, preparing students for 21st century careers and experiences, meeting the increasing demand for the use of innovative classroom practices and technology implementation, and developing a greater satisfaction within their profession. According to Brown (2008), design thinking combines characteristics of empathy, integrative thinking, optimism, experimentalism, and collaboration. To think like a designer, one must demonstrate these characteristics to create for others within parameters, given a specific deadline.

In addition to Brown's definition, Cross examines a broad range of research on design thinking, asserting that "design reasoning is different from the conventionally acknowledged forms

of inductive and deductive reasoning" (Cross, 2011, p. 27). Referring to March's research, Cross points out that "the two conventionally understood forms of reasoning—deductive and inductive—only apply logically to analytical and evaluative types of activity. But the type of activity that is most particularly associated with design is that of synthesis, for which there is no commonly acknowledged form of reasoning" (Cross, 2011, p. 27). Synthesis of knowledge is often a highly desired activity in educational contexts, sitting near the top of Bloom's Taxonomy.

Two additional key elements involved in design practice are that of designing with others, and designing in spaces of ambiguity and unknowns. In an ethnographic study of graphic designers, Murray found that in the graphic design studio, "Briefing sessions take place in the studio in clear sight and sound of everyone. Work in progress is left on drawing boards; discarded sketches, photocopies, printouts and transparencies are left lying around on desks or on the light box … Design is not hidden, it is constructed in public so other people can read it, and accepting commentary on it from somebody else is part of a tradition they embody" (Murray, 1993, p. 306). This social and visible aspect of design is important in the education of today's young people, especially in the current landscape of screen-instigated isolation. In spite of the connected nature mobile devices can provide, school-age children still need to be able to interact in face-to-face environments and be able to successfully navigate conversations and activities that produce critical feedback. These skills are foundational for students who hope to engage in 21st century society. Cross also notes that "the social nature of designing … results in acknowledging the inevitability of uncertainty and ambiguity" (Cross, 2011, p. 20). These skills attributed to design practice, including synthesis of ideas and knowledge, making work visible, and creating with others face-to-face are all important skills that can be taught across any content area in K12 education, not just specific to design education.

What does it look like to practice design thinking as a teacher or student? To begin with, the environment promotes critical thinking and collaboration. While the term critical thinking is

used in abundance in educational curriculum, Ennis provides a specific definition, pertaining more to the present topic of design thinking. Ennis defines critical thinking as "reasonable reflective thinking focused on deciding what to believe or do" (Ennis, 1993, p 180). In an effort to be even more direct, he offers the following tasks that are often associated with the ability to think critically: "Judge the credibility of sources; identify conclusions, reasons and assumptions; judge the quality of an argument, including the acceptability of its reasons, assumptions, and evident; develop and defend a position on an issue; ask appropriate clarifying questions; plan experiments and judge experimental designs; define terms in a way appropriate for the context; be open-minded; try to be well informed; draw conclusions when warranted, but with caution" (Ennis, 1993, p. 180). Many of these tasks are directly involved with engaging in the design process, from collecting valid research, interviewing users, developing ideas, testing and experimenting with potential solutions, and evaluating the effectiveness of those solutions in relation to the needs of the users.

(Lam, Cheng, and Choy (2010) found that school environments that promote collaboration and autonomy provided teachers with the greatest intrinsic motivation to continue teaching. When teachers engage in the design process themselves, they are participating in a collaborative environment that promotes optimism and encourages innovation (Brown, 2008). By using the design process to create new curricula, teachers could experience that same increase in motivation rather than feeling overwhelmed at the daunting nature of the task ahead. When teachers create design learning experiences for students, they are not just creating collaborative projects between the art and math teachers (Archer, Baynes & Roberts, 2005), but they also are creating authentic learning experiences that require students to actively solve problems, apply real-world skills, and create learning that is meaningful to students (Gordon, 2008).

Design Dispositions

In addition to understanding what the design process is, how it can be taught directly, and how it can be applied across content areas, research has also shown that developing design attitudes or dispositions can increase one's success in executing the design process. In a study of 14 designers, Michlewski (2008) identified five specific design attitudes that set apart successful professional designers: consolidating multidimensional meanings, creating, bringing to life, embracing discontinuity and open-endedness, embracing personal and commercial empathy, and engaging polysensorial aesthetics. When applied to the domain of education, the study and application of these dispositions could be effective in developing successful design thinking-based curricula. Much like teachers have begun to understand and teach growth mindsets to students in order to give them the skills to overcome challenges in learning, understanding and teaching design dispositions to both teachers and students can improve the likelihood of carrying out successful design-infused experiences.

Cognitive Theory

To better understand how and why the design process can be a benefit to the practice of teaching, one can look to cognitive theories such as situated learning, distributed cognition, and cognitive apprenticeship. Brown et al.'s (1989) definition of situated cognition states that knowing is inseparable from doing; knowledge comes about as a result of the situation in which it is learned (learning vocabulary by participating in conversation), rather than independently and without context (such as learning vocabulary by reading a dictionary). In the context of learning and teaching design, educators cannot effectively teach design just by reading about design principles, researching design theories, or even implementing design lessons found on the Internet. Rather, Brown et al. (1989) would say that working with designers and collaborating with those who teach design will give new design educators a greater vocabulary with which to teach. Brown argues,

much like Dewey, that authentic learning provides the most meaningful learning experiences, whether the learners are students or teachers.

Lave and Wenger (1991) suggest that members of a community learn because of actively participating in that community, and that knowledge is created by members sharing and applying that knowledge within the situations that develop as the community grows and interacts: "Learners inevitably participate in communities of practitioners and… the mastery of knowledge and skill requires newcomers to move toward full participation in the socio-cultural practices of a community" (Lave & Wenger, 1991, p. 29). Their theory of legitimate peripheral participation describes communities in which new members learn how to interact with the community by observing experienced members, slowly engaging as they take on low-level tasks, and graduating to more complex tasks. This type of environment can occur among a teaching staff, as student teachers observe master teachers and slowly take responsibility of the class, as well as new teachers being mentored by experienced teachers, learning the tricks of the trade through observation, conversation, and practice. In the relatively new field of K12 design education in the United States, this field of experience is growing from the ground up, as teachers are learning by experience how to effectively incorporate design learning into the classroom. Without an established community of experienced K12 design teachers, these educators are creating a body of knowledge, including content and pedagogy, by learning through trial and error, networking with more experienced teachers overseas, and meeting virtually to share and build new knowledge in the field.

The theory of cognitive apprenticeship applies in the domain of teaching as well and can be understood in the modified form of apprenticeship used by teacher education programs through the process of student teaching. The four aspects of traditional apprenticeship include modeling, scaffolding, fading, and coaching (Collins et al., 1991). Student teachers are expected to observe the master teacher model effective teaching strategies, while the master provides scaffolding in the

form of assistance and advice in small tasks, gradually allowing the student teacher to take on more responsibility within the classroom. The master teacher slowly fades away as the head of the classroom, all the while coaching and giving the apprentice teacher strategies for improving classroom instruction.

Collins et al. (1991) describe cognitive apprenticeship as a "model of instruction that works to make thinking visible" (1991, p. 6). Cognitive apprenticeship describes the type of modeling a teacher might demonstrate in a classroom towards students, modeling how to draw a form in a realistic style, scaffolding by giving the student steps for looking and drawing (what to look for, how to hold the pencil, where to make the lines), fading away to let the student try it, and then coaching by periodically guiding the student in the correct drawing techniques as the student works independently.

Combining these methods of traditional and cognitive apprenticeship, teachers can mentor one another to teach new content. Once teachers leave the student teaching experience, they rarely have the opportunity to mentor an experienced teacher in the same manner. Learning to teach new content and teaching methods using the traditional apprenticeship model are all but impossible, as classroom teachers do not have the luxury to give up their time to learn in this manner. However, by creating a virtual community, experienced teachers can effectively use cognitive apprenticeship by modeling through video demonstrations, scaffolding through the sharing of lesson plans, fading away to let the teachers try new methods on their own, and coaching through the use of discussion forums and chat features.

When members of a community mentor, share, and create knowledge with one another, they illustrate the power of distributed cognition; that is, knowledge that comes about as a result of many individuals sharing what they know. The theory of distributed cognition "seeks to understand the organization of cognitive systems," such as a community of educators who work

together to refine their practice (Hollan et al., 2000, p. 175). Within the theory of distributed cognition, Hollan et al. (2000) describe three main aspects:

- Cognitive processes may be distributed across the members of a social group
- Cognitive processes may involve coordination between internal and external (material or environmental) structure
- Processes may be distributed through time in such a way that the products of earlier events can transform the nature of later events (p. 176)

In the specific case of this study of educators who are building a community in which to generate content on design, distributed cognition can help guide the construction of the physical network itself: "Distributed cognition has a special role to play in understanding interactions between people and technologies, for its focus has always been on whole environments: what we really do in them and how we coordinate our activity in them" (Hollan et al., 2000, p. 174). Using this framework, distributed cognition becomes a means for the development of curriculum in K12 design learning as teachers work together to determine best practices for teaching and learning. Additionally, this theory can guide the development of the actual network, providing a framework for how teachers interact with the tools and work materials of the community itself.

Communities of Practice

In the field of teacher professional development, little exists in the form of standardized methods of content, delivery, assessment, measures of effectiveness on student learning, and teacher reflection. While pre-service teachers are required to go through an intense period of student teaching (essentially an apprenticeship), in-service teachers often do not participate in observing other teachers in their practice. In most cases, "in-service teachers have limited opportunities to discuss and observe teaching practices with other teachers because they are often all in their own classrooms at the same time" (Kling & Courtright, 2003, p. 228). This method of teaching and learning goes against the pre-service teaching experience of working closely with a

mentor teacher. When teachers acquire classes of their own, they quickly become isolated within their practice. Though they are accountable to various authorities regarding student test scores, the day-to-day business of teaching is largely unobserved.

According to Wilson and Berne (1999), "Across this incoherent and cobbled-together nonsystem, structured and unstructured, formal and informal, we have little sense . . . of what exactly it is that teachers learn and by what mechanisms that learning takes place" (p. 174). Research shows that teachers who collaborate, engage in meaningful learning experiences, and participate in professional communities demonstrate increased motivation and retention (Brown, 2008; Kling & Courtright, 2006; Lam, Cheng, & Choy, 2010). Because time and location often affect how teachers interact with one another, online technology has become a possible solution to the problems mentioned. Focusing on the specific content area of design education, this paper seeks to understand how teachers can effectively participate in these types of learning experiences by using online and physical communities and the research-based best practices surrounding the development of design-based teacher communities.

In addition to learning about design and methods for teaching design, teachers need a support system to help them through the process of teaching a new subject. By forming a community based on their interest in design education, teachers can have access to both existing and new knowledge about methods of teaching design. Wenger defines this type of community as a community of practice, or "groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly" (Wenger, 2011, p. 1). Research shows that "through a community of practice teachers can become less isolated and more inclined to discuss new ideas, can solve problems that arise concerning technology integration, and can form a support system to foster new ideas" (Vavasseur & Macgregor, 2008, p. 519). Developing a design education-focused community of practice would allow teachers to both learn about design

and interact with experienced design educators, fostering the type of relationship found between the student and cooperating teacher.

Wenger (2011) outlines three characteristics that determine if a community is actually a community of practice*:* they must have a domain (the area of interest), a community (people who actively engage in activities or discussions), and a practice (they are active practitioners in their area of interest) (p. 1-2). For this paper, the community of practice includes K12 design education (the domain), interested educators in both K12 and higher education (the community), and the implementation of design teaching (the practice). Once established, these "communities of practice can play important direct and catalytic roles in teacher learning" (Schlager & Fusco, 2003, p. 206), contributing to the speedy dissemination of knowledge about design education.

Virtual Communities of Practice

When communities of practice were first defined, some research found that the main reason for their success was due to face-to face interactions and the personal relationships that were developed through those interactions (Brown & Duguid, 1991). As online communities have emerged over the last two decades, the question remains if an online community can successfully develop into an online community of practice. According to a study on online communities of practice, "It is one thing to create a technical environment that allows organizational members to communicate with each other online; it is another thing to see a community emerge from the connected members" (Zheng & Watts, 2008, p. 56). Teachers interested in design education are spread out across the United States, and online communities are often the only way they can connect; personal, face-to-face interactions are difficult, if not impossible, to coordinate. A brief Internet search returns a handful of K12 design education-related networks, but none have the qualities of a community of practice. Based on the desire within the design education community, is there enough interest, leadership, and accountability to develop a community of practice? Zhang

and Watts (2008) note that "few studies have convincingly demonstrated that CoPs can emerge from online communities" (p. 56).

While many virtual communities exist, what sets them apart from communities of practice? To begin with, "online CoPs are more resource intensive than other types of online social structures" (Zhang & Watts, 2008, p. 67). The large amount of resources proves to be ideal for teachers, who are often searching for new and innovative resources to use in their classrooms. Ardichvili (2008) defines a virtual community of practice (VCoP) as a place where "community members share and cocreate knowledge in online discussions and other forms of knowledge exchange" (p. 1). Unlike face-to-face communities, members rely on computer-mediated forms of communication. This type of communication does not afford the benefits of an in-person discussion: reading body language, voice inflection, and other non-verbal forms of communication. To establish relationships with community members online, members must become active contributors to the online environment. Key elements to developing a practice online are the acts of receiving, sharing, and creating new knowledge. When members of an online community are actively engaged in knowledge sharing and creation, they move beyond the boundaries of mere online communities. Within the virtual community of practice, "Information contribution is not only an act of sharing or exchanging resources but also a symbolic one that forges and maintains a relationship between an individual and a collective" (Jian & Jeffres, 2006, p. 247).

Research has shown that these online communities of practice provide many benefits to teachers, especially when they follow certain structural guidelines. In a study on math and science teachers who participated in an online community of practice related to science and math education, "Teachers who normally do not communicate with one another were able to engage in reflective practice and provide support for each other in adopting innovation" (Vavasseur & MacGregor, 2008, p. 533). Additionally, the study found that in the online community, teachers

demonstrated greater levels of self-reflection, including sharing their thoughts regarding ethical issues and personal beliefs within the context of their classrooms (Vavasseur & MacGregor, 2008). In another study, researchers found that teachers received even more benefits by engaging in embedded communities, or communities where members interact both face-to-face and online. Research has shown that these types of blended communities afford the greatest benefit to teachers because the physical interaction develops greater trust between members (Matzat, 2012).

Trust within online communities can be both a hindrance and a benefit. In face-to-face meetings, "Teachers who share experiences of troubled teaching, and even of failure, risk being viewed as incompetent by their peers" (Kling & Courtright, 2003, p. 227). While establishing trust in physical environments is difficult enough, building trust in an environment where members may have never met one another can be even more challenging. A lack of trust can prevent an online community from ever reaching a fully functioning community of practice. Active involvement on the part of community facilitators can make or break the success of an online community: "Trust does not automatically develop for many groups online; it may require significant intervention for e-forum organizers to foster trust, either online or face-to-face, or both" (Kling & Courtright, 2003, p. 228). Just as in a physical classroom, the teacher must set the tone for how students are to behave and interact with one another to build the classroom community, the moderators of VCoPs must establish the tone of the community through sharing and promoting interaction among the community members. When trust is developed in the VCoP, the quality of knowledge sharing is often increased (Chiu, et al, 2006).

The most successful online communities of practice incorporate blended learning opportunities (Matzat, 2012). While blended learning can mean a multitude of things in student learning, blended experiences ("embeddedness") within the context of VCoPs means that members engage in both online and physical interactions. Not all community members have to know each other in real life to receive the benefits of blended communities. In Matzat's study (2012) of

blended learning communities, he found that "under a high embeddedness teachers are more willing to trust each other, they are more motivated to share teaching material and engage in useful discussions" (Matzat, 2012, p. 48). Ardichvili (2008) similarly found that face-to-face meetings and video-conferencing helps community members build a sense of trust and a familiarity with one another's appearance and non-verbal cues (Ardichvili, 2008, p. 551).

As members of the community begin to develop a sense of trust with one another, they are able to engage in more open forms of knowledge sharing; without that trust, members are likely to stay quiet within the group, even though they may seek out resources from the online environment (these quiet members are known as "free-riders," those who want the benefits of the community but do not actively participate in the community). When it comes to knowledge sharing, "the biggest challenge in fostering a virtual community is the supply of knowledge, namely the willingness to share knowledge with other members" (Chiu, Hsu, & Wang, 2006, p. 1872). Ardichvili (2008) found that barriers to knowledge sharing included members' fear of criticism, lack of technological skills, lack of community norms, and a lack of knowledge about how to supply information to the online community. To avoid these barriers, moderators of the virtual community should clearly communicate the purpose and benefits of sharing knowledge. They should also seek to create and maintain relevant norms for the community so that members understand how to effectively contribute to the discussions.

Aside from barriers of trust, fear, and a lack of knowledge about how to interact in the online community, several studies showed that teachers in online communities were hesitant to critique one another. A common finding was "the reluctance of teachers to engage in inquiry or dialogue that critiques the practice of their peers" (Schlager & Fusco, 2003, p. 205). Whether or not teacher communities demonstrated high or low levels of trust, they were still uncomfortable with taking professional risks, including acknowledging their own weaknesses and pointing out the failures of others (Kling & Courtright, 2003). This is yet another area where moderators can

intervene and set the tone for conversations about the improvement of the teaching practice. Setting guidelines for critique and following up when members abuse those guidelines can create an atmosphere where teachers feel comfortable recognizing areas for improvement.

Online Teacher Professional Development

Another strand of research related to online teacher communities is that of online teacher professional development (oTPD). Unlike many other online communities of practice, teachers are not only interested in their own learning but also in the learning of their students. The primary goal of teacher professional development (TPD) is to increase student learning through teacher training. Schlager and Fusco (2003) define the purpose of TPD as "a career-long, context-specific, continuous endeavor that is guided by standards, grounded in the teacher's own work, focused on student learning, and tailored to the teacher's stage of career development" (p. 205). Noting its direct relationship to communities of practice, they add, "It is a process of learning how to put knowledge into practice through engagement *in* practice within a community of practitioners" (Schlager & Fusco, 2003, p. 205). Typical professional development experiences leave teachers feeling like it is a waste of time and resources and that they do not have the support necessary to implement the lessons learned in their classrooms (Dede et al., 2009). Especially regarding technology, teachers become frustrated with the amount of extra work required to accommodate new teaching materials and as a result of this frustration, often leave the new technology options out of the classroom completely (Cuban, 1986).

The introduction of online teacher professional development has become a way of offering TPD to teachers that is both flexible and asynchronous with regards to time and communication. While "little is known about best practices for the design and implementation of these oTPD models," the current research shows that oTPD is attempting to use the VCoP framework to "promote collaboration and reflection" (Dede et al., 2009, p. 9). In a study of middle school teachers' use of an online TPD module, researchers found that the "teachers used the online

community as a forum to identify problems and to share potential solutions" (Vavasseur & MacGregor, 2008, p. 530), actively participating in the knowledge sharing that defines online communities of practice. In Dede's study of oTPD, asynchronous and non-physical communication allowed for the increase in "the contributions of teachers who tend to be silent in face-to-face settings but 'find their voice' in mediated interaction," (Dede et al., 2009, p. 9). It is possible that the focus on student learning, as opposed to the shortcomings of teachers themselves, helps teachers become more motivated to participate in the online communities. It is also worth researching teacher efficacy in relationship to online teacher professional development: when teachers are given more autonomy in choosing when and how to participate in professional development, do they find greater benefits? If a teacher-centered VCoP were developed for the purposes of building knowledge in the field of design education, would it be more successful if it followed oTPD models?

Considering the examination of a proposed community of practice for geographically dispersed design educators, several recommendations can be gleaned from the research. First, many online communities are just that: communities. What separates these communities from communities of practice is the collaborative creation of new knowledge within the practice. As the studies have shown, new knowledge cannot be created without first having a community of members who trust one another enough to share knowledge. That trust is established first by the community moderators who set the tone and determine the culture of the community: "Creating and maintaining a set of core and experienced individuals plays an important role in developing and sustaining a professional virtual community" (Chiu et al., 2006, p. 1885). The stakeholders involved in the creation of the initial community should incorporate the culture of the community in every aspect of its existence, from the visual appearance to the navigation to the tone of the posted messages. For designers, they may be more familiar with the idea of branding as a way of communicating the values of the group.

Second, members must be clear about how to interact within the community. They should be able to understand what types of communication are available and how to function within each type. This can be achieved in the actual architecture of the online community. Members should be able to easily find one another and instigate a collaborative relationship. Schlager and Fusco (2003) suggest members should be able to "build and manage their professional identity, find and collaborate with one another, and function in multiple roles" (p. 213), such as participating in one group while facilitating another. Some web platforms are better equipped than others to handle certain styles of communication. For example, "Course management technologies used in most e-learning applications [such as Blackboard] may not be the most appropriate for informal, highly contextualized learning in an education community of practice" (Schlager & Fusco, 2003, p. 213). Though course management systems are used for educational purposes, they may not facilitate the needs of the teachers in a specific community nor are they always easy to navigate for new users.

Third, teachers need a way to share and create knowledge that is meaningful and relevant to the teaching practice. These "education communities of practice could benefit from online capabilities that make it possible to create, manage, reuse, and modify workplace artifacts (e.g., lesson plans, assessments, action research, student and teacher portfolios)" (Schlager & Fusco, 2003, p. 213). Having a way to easily create, store, and search these artifacts will make the community more attractive to free-riders, possibly encouraging less-involved members to actively seek out information and ask questions of those creating the artifacts.

As the design education community grows and takes shape, the stakeholders have a multitude of research to assist in the development of a community of practice. By following the recommendations outlined above, the community should be well on its way to establishing a new body of knowledge in the field of K12 design education in the United States. Countries around the world, especially in England (Cross, 2007) and Singapore (Design and technology syllabus, 2006), have embraced design education. By taking advantage of the global network available through the

Internet, teachers in the United States can collaborate with and learn from design educators all over the world.

CHAPTER 3

METHODOLOGY

Introduction

Bjorn and Boulus (2011) define action research as "having a primary purpose of responding to local and practical concerns while producing practical knowledge useful to organizations and communities" (p. 284). The primary goal of this specific study is to do just that: respond to concerns of teachers who wish to learn more about and teach design learning by providing them with the practical knowledge to apply design methods in the classroom. This information could be used for a variety of applications, including the creation of standardized teacher professional development in the areas of design thinking and learning, design standards or guidelines for the K12 classroom, and course development for pre-service and continuing education teachers looking to implement design thinking and learning in their future classrooms. For this study, a solution could include an active community of practice, a digital network, or a framework that provides teachers with the necessary knowledge, resources, and support system to implement design-based experiences across the K12 curriculum while adhering to 21st century skills as well as content-based standards.

The methodology used to collect data for the research questions is listed in this chapter. The following is a list of the individual sections: 1) introduction, 2) research questions, 3) research design, 4) participants, 5) data collection, 6) data analysis, and 7) summary.

Research Questions

1. What core guiding principles of design thinking are most important, relevant, and feasible in K12 education?
2. What are the best methods for K12 educators to learn and share knowledge about teaching design thinking?
3. How might educators best prepare for implementing design thinking in the

21st century classroom?

Research Design

Because this study involves both education and design, research methods from both disciplines were used to gain the greatest possible insight, knowledge, and professional benefit. The study was conducted using a qualitative action research method, which is a research method that "contributes actively to processes of democratic social change," (Greenwood & Levin, 1998). Unlike more traditional methods of quantitative research, "Action research is enquiry with people, rather than research on people" (Altrichter, et al, 2002, p. 130). This method is appropriate because the study seeks to involve multiple stakeholders of design learning in working together to create a functional and useful solution for collaboration that will hopefully bring about changes in the teaching of those involved. What "distinguishes action research from most other research approaches, and also constitutes one of its main appeals, is that action research aims at both improving the subject of the study (often called the research "client"), and generating knowledge, achieving both at the same time" (Kock, 2011, p. 2). Within the action research framework, the researcher is actively involved with the research participants working together to implement a course of action (Anderson & Herr, 2005).

Additionally, action research makes for an appropriate choice in educational research because it "is oriented to problem-solving in social and organizational settings, and... has a form that parallels [John] Dewey's conception of learning from experience" (Smith, 1996). Whereas the quantitative researcher develops a hypothesis and then tests it, often using control and experimental groups, collecting and analyzing statistical data, the action researcher, along with research participants, goes through an iterative sequence of steps to reach a final goal. While several action research models exist for this type of study, this study will incorporate those from Kemmis (1982): developing a course of action (plan), implementing that plan (act), observing the effects of the action (observe), and reflecting on those observations (reflect). Should the course of

action require additional investigation (and it usually does), the sequence begins again, and the researcher works with participants to further revise and reflect on the second iteration of the plan, therefore making action research more cyclical than other types of research methods (Kemmis, 1982). For this study, the following chart outlines the Kemmis model of the Action Research framework. This model was chosen because it closely mirrors the steps of the design process, seen in Figure 1.

ACTION RESEARCH FRAMEWORK

PLAN	Research the problem and work with stakeholders to determine needs and challenges regarding learning about and implementing design thinking
ACT	Connect with stakeholders and conduct research on what tools and processes would be best to help them learn about and implement design thinking
OBSERVE	Collect qualitative and quantitative data from stakeholders and educators in the form of surveys, interviews, and any additional media as necessary
REFLECT	Analyze data to determine next steps in action plan

(From Kemmis, 1982)

Figure 1. Action research framework

Using a process for design thinking is an iterative sequence of steps in which designers use a variety of problem-solving skills to create a new product or idea. While there are multiple models of the design thinking process, they generally include several main areas. This research study will incorporate an adaption of a model developed by IDEO in conjunction with K12 educators. The stages include: research (what is the problem? what are the needs?), define (determine the parameters of the problem), brainstorm (what are all the possible ways of solving the problem?),

prototype (choose the best ideas, develop basic models and try them out with users), reflect (collect user data, and revise if necessary) (IDEO, 2011). These stages are often both iterative and reflective, as designers continually redesign and retest ideas to fully meet the needs of their users. Throughout this study, as stakeholders prototype and iterate their best ideas, they will use the design process stages to guide the overall development, seeking to create a solution that serves the needs of everyone involved.

The combination of action research and design research methods mirror one another, providing further evidence that these methods are appropriate for this study. In Figure 2, notice how the stages of both action research and the design process are similar in nature.

Design Process and Action Research Compared

DESIGN PROCESS	DESCRIPTION	ACTION RESEARCH
RESEARCH	Gather information	**RESEARCH**
DEFINE	Determine steps	**PLAN**
BRAINSTORM	Develop ideas	**PLAN**
PROTOTYPE	Take action	**ACT/OBSERVE**
REFLECT	Reflect and revise	**REFLECT**

(From IDEO, 2010, and Kemmis, 2011)

Figure 2. Design process and action research compared

Just as the design process is both iterative and emergent, the action research process requires continuous reflection and evaluation. Data collection and analysis can change depending

on the direction of the design and participants (Anderson & Herr, 2005). According to Kock (2011), "In Action Research the researcher uses participant observation and interviews as key data collection approaches. Although typically applying very little, if any, control on the environment being studied, the researcher is expected to apply some form of 'positive' intervention" (p. 4). In this case, the positive intervention will be the collaborative community. Following this methodology, the data collection methods for this design included interviewing and surveying all major participants over the course of the design process, including collecting both qualitative and quantitative data. Educators who participated in and contributed to the community were surveyed as well. In addition, the researcher maintained a descriptive research journal and provided detailed content analysis of all documentation.

Participants

The participants in this study included three distinct groups, all purposive samples with varying degrees of interest and experience in learning and teaching design. The groups ranged in size, proximity, profession, and content area. Figure 3 describes key characteristics of each group.

RESEARCH PARTICIANTS

GROUP 1	Existing group of designers and educators Collaborate and communicate infrequently Geographically dispersed
GROUP 2	K12 art educators Collaborate and communicate quarterly Single suburban school district
GROUP 3	Secondary CTE educators from multiple content areas Collaborate and communicate quarterly to weekly Single suburban high school

Figure 3. Research participants

The first group (G1) includes an existing group of designers and educators who are loosely affiliated with a non-profit organization that promotes K12 design learning; they are currently seeking to design a network geared towards promoting design in K12 schools nationally. The members of this group include K12 educators, higher education instructors, and industrial designers. At the outset of this study, this group identified high familiarity with the design process, and most group members are involved in teaching and sharing design thinking and learning in the K12 classroom. This group is geographically dispersed across the United States and has infrequent opportunities to meet; they do not have any regular communication or collaboration.

The second group (G2) includes a selection of 37 K12 art teachers from a single suburban school district. At the outset of this study, this group of educators identified some familiarity with the design process though many have not had training using it in the K12 art room. This group meets either each quarter or each semester throughout the school year, and smaller subsections (related to grade level and/or feeder schools) meet more frequently.

The third group (G3) includes a selection of seven high school teachers from the same suburban school district mentioned above. These seven teachers represent a variety of content areas and are from one high school. At the outset of this study, this group of educators also identified familiarity with the design process but have not had training using it in the secondary classroom. This group can meet frequently because they are in the same building. The group reported being able to meet as frequently as weekly and as infrequently as once per semester.

Human Subjects Issues

The Review Board for the school district granted permission for the study. The Human Subjects Research Committee at the University of Kansas approved this study as well. This study consisted of qualitative Questionnaires and interviews. All personalizing information was removed from the data providing an anonymous data set.

Data Collection Procedures

Action research uses both qualitative and quantitative data to gather insight about the research problem at hand. Each research question seeks to inform a part of the design process, and as such, the data collection methods were unique to each stage of the process.

RQ1: What core guiding principles of design thinking are most important, relevant, and feasible in K12 education?

To address RQ1, which essentially frames the design problem, extensive research in the current landscape of design thinking and learning was necessary. A comprehensive document analysis was conducted to build a full and complete picture of the history and theory of design thinking as well as its practical applications in education and industry. Bowen (2009) writes that "documents provide background information as well as historical insight. Such information and insight can help researchers understand the historical roots of specific issues and can indicate the conditions that impinge upon the phenomena currently under investigation" (p. 29). The analysis for RQ1 included a careful selection of documents pertaining to the three qualifiers of RQ1: important, relevant, and feasible. To answer what principles are most important, the researcher chose to focus on definitive writings about design thinking and cognition, selecting writings from design and cognitive theorists Schon (1973), Cross (2007), Dewey (1938), and Papert (1991). To answer the question of what principles are most relevant, research focused on current design thinking trends in industry, as demonstrated by companies IDEO and IBM, and the leading executive education programs of the Stanford d.school, MIT, and Harvard. Last, to determine which guiding principles would be most feasible for K12 education, data was collected from global models of design standards in England and Singapore as well as the latest revision of K12 educational content standards in the United States including Common Core State Standards, NextGen Science Standards, National Core Art Standards, and the International Society for Technology in Education standards.

Bowen (2009) offers the rationale that document analysis can provide qualitative research with additional questions that need to be asked and situations that need additional research to provide a broader scope of the problem at hand. In the instance of this research question, the documents selected and analyzed were specifically chosen to corroborate a variety of perspectives on design thinking to construct meaningful guiding principles before moving forward with implementing the Act phase of the action research study. Figure 4 outlines the documents selected for analysis.

DOCUMENTS SELECTED	DATA ANALYZED
THEORETICAL APPROACHES	
Archer, B. Design as a discipline (1979)	Defining features of design as a discipline separate from the study of sciences and humanities
Cross, N., Designerly ways of knowing (2007)	Characteristics of the cognitive processes and activities of design
Dewey, J., Experience and education (1938)	Characteristics of the processes and activities of learning and learning environments
Papert & Harel, Situating constructionism (1991)	Characteristics of knowledge construction
Simon, H. The sciences of the artificial (1969)	Defining characteristics of the activity of design thinking
Wasserman, A., Thinking about design thinking, recorded presentation (2011)	History and trajectory of design thinking as both a defined term and cognitive activity
Waks, L. Donald Schon's philosophy of design and design education (2001)	Characteristics of the teaching and learning of design
K12 CONTENT STANDARDS	
Common Core State Standards: Mathematical practices, College and career readiness anchor standards (2010)	Learning standards for K12 math, language, reading, writing, communication
ISTE Standards for students (2016), ISTE Standards for educators (2008)	Learning standards for students and teachers in technology
NextGen Science Standards (2013)	Learning standards for science
National Core Arts Standards (2014)	Learning standards for fine and performing arts including visual arts, music, dance, theater, and media

Partnership for 21st Century Learning, Framework for 21st century learning (2007)	Recommended framework for learning 21st century skills in K12 education
GLOBAL DESIGN STANDARDS	
Singapore, Design and technology syllabus (2006)	Learning standards and assessment protocols for design and technology in secondary schools
National curriculum in England: Design and technology programmes of study (2013)	Learning standards and key stages for design and technology for primary and secondary schools
National curriculum in England: Art and design programmes of study (2013)	Learning standards and key stages for art and design for primary and secondary schools
INDUSTRY APPLICATIONS	
Brown, T. Design Thinking (2008)	Characteristics of design thinking and design thinkers
IDEO, How we work (2017)	Principles and processes of design thinking at IDEO
Solomon, A. How to do design thinking, Interview with David Kelley (2013)	Descriptive analysis of steps of IDEO's design process
IBM, Design thinking principles and loop (2017)	Principles and processes of design thinking at IBM
Stanford d.school, How we do it, Core abilities (2017)	Principles and processes of design thinking at Stanford d.school
MIT, Professional short programs (2017)	Design thinking for business professionals
Harvard Graduate School Executive Education (2017)	Design thinking for business professionals

Figure 4. Document analysis chart

Just as in both action research and the design process, the first step is to research the problem and gather information before brainstorming possible solutions. As Bowen (2009) suggests for the procedures of document analysis, these selected documents were first skimmed, then thoroughly examined, and finally interpreted and analyzed for determining categories and

common themes. A comparative chart was developed to analyze similarities and differences and demonstrate the interconnected themes.

RQ2: What are the best methods for K12 educators to learn and share knowledge about teaching design thinking?

RQ2 required more direct data collection as well as multiple cycles of data collection. For the purposes of this study and RQ2 in particular, three cycles of implementation and data collection were conducted (see Figure 5).

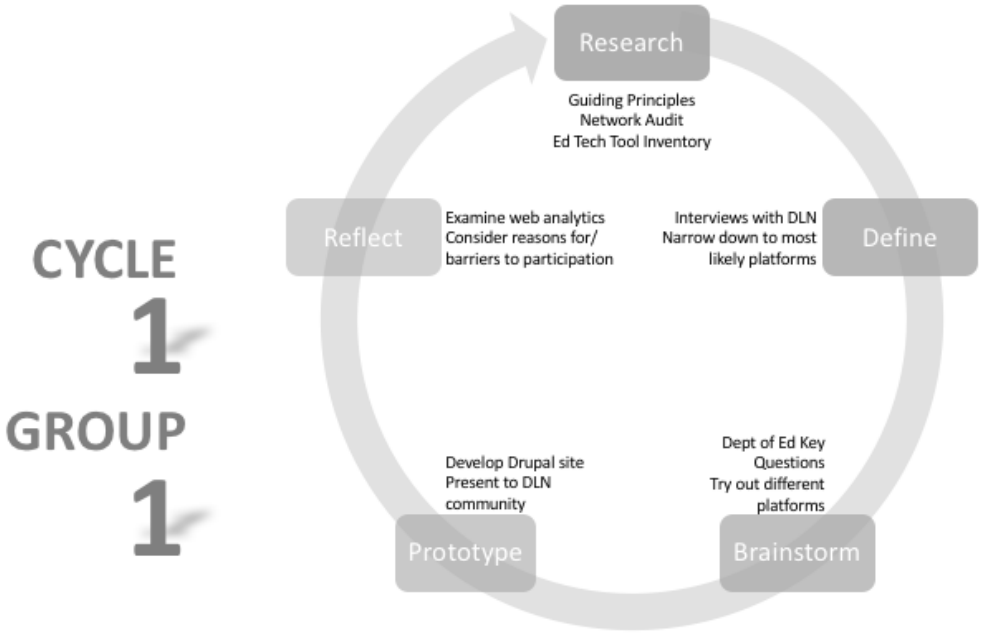

Figure 5. Implementation of Cycle 1

Cycle 1 began the Research phase of the design process with an initial investigation of existing communities of practice centered on the goal of learning and sharing information about K12 design thinking and learning plus an inventory of collaborative tools for sharing and creating knowledge related to design thinking and learning. Based on the information audit, the design process led to informal interviews with stakeholders of the non-profit organization from Group 1. Interviews were conducted and recorded on-site during a conference when several key members of

the organization were present; the recordings were transcribed later and analyzed for common themes and concepts. The informal interview questions from Cycle 1 are in Figure 6.

GROUP 1
Informal Interview Questions

1	What do you envision as the best possible way to connect educators across the country who are interested in design thinking in the classroom?
2	What types of interactions should educators be able to have in order to share their successes/challenges with design thinking in the classroom?
3	What else should educators be able to share with one another?
4	How do you envision collaboration happening when educators are so spread out?
5	What ideal outcomes do you see emerging as a result of this collaboration?

Figure 6. Group 1 informal interview questions

In addition to answers from these interview questions, Cycle 1 also included data collected from transcribed notes taken from a brainstorming session with stakeholders and web analytics from the first roll-out of the online community that was developed from the brainstorming session.

After Cycle 1 was completed, a second cycle was initiated to gather additional data on the effectiveness of the website as a tool for collaboration in implementing design thinking. Note that the second and third cycles both begin with the Brainstorm step, as research and planning had already been established (see Figure 7).

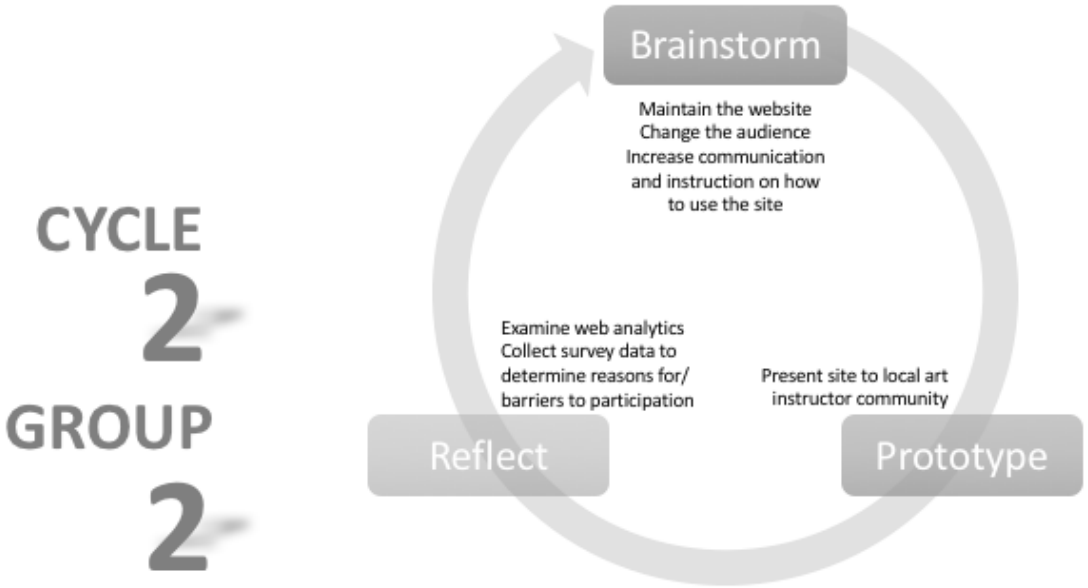

Figure 7. Implementation of Cycle 2

Data collection from Cycle 2 was to include a second round of web analytics from Group 2. Upon finding that no users participated in the website, which meant that no web analytics were collected, a questionnaire was generated to investigate possible reasons why the website had not gained traction in either group. Thirty-seven responses were collected from fifty total questionnaires sent to Group 2. The questionnaires are in Figure 8. The questions were developed to gain understanding about existing use of online communities, interest, and experience in the design process, as well as levels of interest in collaboration, whether physical or virtual. At this point in the research process, access to Group 1 had been discontinued.

GROUP 2
Survey Questions

1	What level do you teach primarily?
2	How many years have you been teaching?
3	What subject do you teach primarily?
4	Approximately how many online communities are you currently involved in?
5	For what reasons do you participate in online communities?
6	If you do not participate in any communities, for what reasons do you not participate?
7	What benefits do you gain from participating in online communities?
8	Approximately how much time do you spend engaging in online communities? (This can include viewing, reading posts, downloading documents, contributing content, or any other interaction with the community)
9	Are you involved in any communities (physical or online) that include content relating to the design process? If so, please describe the community.
10	As a teacher, what would be most helpful in supporting your understanding and implementation of the design process in your practice?
11	How often do you communicate with course/content-alike colleagues outside of your building? (multiple choice response)
12	What methods do you prefer using to connect and/or collaborate with your colleagues? (checkbox response)
13	What technology tools do you prefer for online collaboration? (checkbox response)
14	Do you have any interest in collaborating with teachers outside your district, region, or country?
15	What types of projects would you be interested in collaborating on via long distance?
16	What methods/tools would you prefer to use on a collaborative project outside your building and/or district?

Figure 8. Group 2 questionnaire

After survey results were collected from Cycle 2, a third and final cycle was initiated. For the third cycle, the online community was abandoned and a workshop approach was identified as the next and final iteration of learning and sharing knowledge about design thinking. Additionally, a third and final group of seven participants was identified to test the workshop model (see Figure 9).

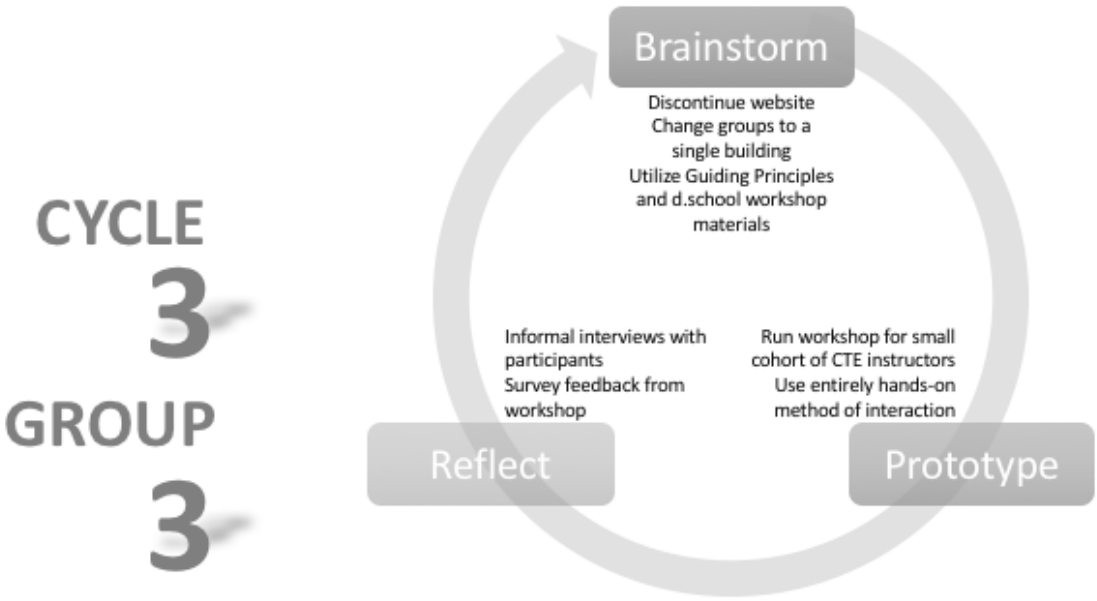

Figure 9. Implementation of Cycle 3

Data collection from Cycle 3 included detailed notes, email communications, and collaborative planning documents regarding the development of the workshop. Following the conclusion of the workshop, a post-experience feedback questionnaire was collected to examine participants' attitudes towards their experience of learning about and implementing the design process in their classrooms using the workshop method. The questions from the feedback questionnaire are in Figure 10. Four responses were submitted from the seven total workshop participants.

GROUP 3
Post-Workshop Reflection Survey

PRIOR KNOWLEDGE	
1	How familiar were you with the design process before the workshop? (Likert scale)
2	Did the workshop experience increase your knowledge of the design process?
3	Did the workshop increase your level of comfort in teaching the design process in your classroom?
WORKSHOP EXPERIENCE	
4	What was the most beneficial part of the workshop?
5	Did the use of technology have any impact on your participation in the workshop?
6	Did the use of technology have any impact on your implementation or collaboration since participating in the workshop? Please explain
7	Are there any technology tools you are currently using or wish to use in implementing the design process in your teaching?
WORKSHOP IMPACT	
8	Has your workshop experience impacted your teaching?
9	Has your workshop experience impacted student learning?
10	Overall, what has been your greatest takeaway from the workshop?
RECOMMENDATIONS FOR SHARING DESIGN PROCESS	
11	Do you think all educators should be trained in using the design process?
12	In your opinion, please rank the following methods of introducing other educators to the design process (checkbox response)
13	What resources best helped you in learning about how to use/teach the design process, whether on your own, in your classroom, or for other purposes? (checkbox response)

Figure 10. Group 3 post-workshop reflection questionnaire.

The data collected from the feedback questionnaire was coded and analyzed for common themes in the Workshop Experience and Workshop Impact categories. The recommendations were compiled into a separate chart. Criteria were established from the common themes and

recommendations, and these criteria were used to inform the development of the framework in RQ3.

RQ3: How might educators best prepare for implementing design thinking in the 21st century classroom*?*

RQ3 represents the final phases of the design and action research processes, where data collected from testing the prototypes was analyzed and used to develop more refined solutions. The final phase of this research study included a rigorous analysis of the data collected from the three cycles of implementation in RQ2, which led to the proposed framework for teaching educators how to learn about, implement, and share the design process. Because of the success of the third iteration of the research cycle, data collected from the development of and feedback from the workshop were used to create the proposed framework.

Role of the Researcher

Throughout the study, the role of the researcher will be defined as an "outsider in collaboration with insiders" (Anderson & Herr, 2005, p. 2). This means that the researcher works alongside the participants in the study, but not necessarily in an equal role. In this position, the researcher is expected to contribute to the knowledge base, help develop improved practice, and provide professional transformation because of the study (Anderson & Herr, 2005). As the researcher, my experience as a K12 educator and educational technology and design doctoral student allows me a unique perspective with which to engage in participatory design as well as collect data throughout the process.

Limitations of the Study

To focus primarily on the process of networking and advancing design education through collaboration technology, this study did not seek to examine specifics of design curriculum, such as what standards should be assessed, at what grade levels design should be taught, and how it can be integrated into the current national standards, even though these discussions are all happening

simultaneously. The primary focus of the study will be on how stakeholders go about having these discussions and how they convey that information to colleagues. Additionally, limitations included access to the first group, as communication with the non-profit was discontinued after several months of the website remaining dormant. Last, as in many action research studies, the results will most likely not be generalizable to larger populations; the research is intended to transform the specific populations addressed in the study.

Reliability and Validity

Stringer suggests that action research "uses a different set of criteria" when it comes to determining reliability and validity. Because it is highly qualitative in nature, "rigor in action research is based on checks to ensure that the outcomes of research are trustworthy," (Stringer, 2007, p. 92). Lincoln and Guba (1985) found that trustworthiness in a research study can be established by determining if a study has credibility, transferability, dependability, and confirmability. Stringer (2007) recommends several techniques for establishing credibility in an action research study including persistent observation (showing participants that the researcher is actively and continually involved in documenting the situation rather than recalling from memory or telling the story from the researcher's perspective), participant debriefing (helping participants express feelings and emotions as a result of participating in the study), and diverse case analysis (making sure all stakeholder opinions are a part of the study).

While action research is not intended to create generalized solutions to broad audiences, the concepts learned through the research process can still be transferred to other situations. For example, this research study will demonstrate transferability if other content-specific educators wish to develop a framework for sharing and creating knowledge. The research study will be able to demonstrate dependability if the participants believe the research process has been followed systematically and methodically. Last, a compendium of documentation of the process should be presented in detail to demonstrate the confirmability of the research process.

Data Analysis

Qualitative data analysis methods will be used for most of the qualitative data collection, including coding, categorizing, and identification of key concepts. Where appropriate, quantitative analysis methods will be employed.

CHAPTER 4

RESEARCH RESULTS

The results of the data analysis for each research question will be presented in this chapter in five sections. The first section is an introduction to the study. The second section describes the results of the first research question and identifies seven guiding principles for teaching design thinking and learning in K12 schools. The third section addresses the results from the second research question and incorporates data analysis from each successive phase, and it describes in detail the results from implementation of three iterations of methods for sharing and learning about the design process. The fourth section draws connections between the first two research questions and proposes a framework for teaching design thinking and learning as the response to the third research question. The fifth section summarizes the results.

Introduction

The purpose of this study was to examine the current landscape of design thinking in education and both its role in and impact on K12 educational innovation; observe how a potential K12 design thinking-based community of practice develops, interacts, and supports innovation using a variety of physical and technological processes; and use the design process to research and engage the stakeholders involved in order to develop solutions that attempt to address the problem of teaching educators how to effectively use the design process to solve problems in education. The following research questions were created to address the study's purpose:

1. What core guiding principles of design thinking are most important, relevant, and feasible in K12 education?
2. What are the best methods for K12 educators to learn and share knowledge about teaching design thinking?
3. How might educators best prepare for implementing design thinking in the 21st century classroom?

Research Question 1

RQ1: What core guiding principles of design thinking are most important, relevant, and feasible in K12 education?

Following both the design process used for this action research study, as well as Betty Garner's five instructional steps, this question sought to research, explore and define the problem space, wherein K12 educators in the United States lack consistent and defined principles, standards, and processes for both learning and teaching design thinking across content areas. To answer this question, a document analysis was conducted to identify key characteristics of design thinking across four domains: theoretical and research-based approaches to design thinking in education, K12 content-area standards in the United States, K12 design standards around the world, and post-secondary (including higher education and industry) standards of design thinking. Theoretical and research-based documents were selected to satisfy what is most important in K12 education; documents relating to K12 standards, both in the US and abroad, were selected to satisfy what is most feasible, as they are already being taught in schools around the world; and documents from industry and professional standards of design thinking were selected to demonstrate what is most relevant, as they are what students will experience upon entering the workforce. Figure 11 outlines the specific texts chosen for the document analysis.

DOCUMENTS SELECTED	DATA ANALYZED
THEORETICAL APPROACHES	
Archer, B. Design as a discipline (1979)	Defining features of design as a discipline separate from the study of sciences and humanities
Cross, N., Designerly ways of knowing (2007)	Characteristics of the cognitive processes and activities of design
Dewey, J., Experience and education (1938)	Characteristics of the processes and activities of learning and learning environments
Papert & Harel, Situating constructionism (1991)	Characteristics of knowledge construction
Simon, H. The sciences of the artificial (1969)	Defining characteristics of the activity of design thinking
Wasserman, A., Thinking about design thinking, recorded presentation (2011)	History and trajectory of design thinking as both a defined term and cognitive activity
Waks, L. Donald Schon's philosophy of design and design education (2001)	Characteristics of the teaching and learning of design
K12 CONTENT STANDARDS	
Common Core State Standards: Mathematical practices, College and career readiness anchor standards (2010)	Learning standards for K12 math, language, reading, writing, communication
ISTE Standards for students (2016), ISTE Standards for educators (2008)	Learning standards for students and teachers in technology
NextGen Science Standards (2013)	Learning standards for science
National Core Arts Standards (2014)	Learning standards for fine and performing arts including visual arts, music, dance, theater, and media

Partnership for 21st Century Learning, Framework for 21st century learning (2007)	Recommended framework for learning 21st century skills in K12 education
GLOBAL DESIGN STANDARDS	
Singapore, Design and technology syllabus (2006)	Learning standards and assessment protocols for design and technology in secondary schools
National curriculum in England: Design and technology programmes of study (2013)	Learning standards and key stages for design and technology for primary and secondary schools
National curriculum in England: Art and design programmes of study (2013)	Learning standards and key stages for art and design for primary and secondary schools
INDUSTRY APPLICATIONS	
Brown, T. Design Thinking (2008)	Characteristics of design thinking and design thinkers
IDEO, How we work (2017)	Principles and processes of design thinking at IDEO
Solomon, A. How to do design thinking, Interview with David Kelley (2013)	Descriptive analysis of steps of IDEO's design process
IBM, Design thinking principles and loop (2017)	Principles and processes of design thinking at IBM
Stanford d.school, How we do it, Core abilities (2017)	Principles and processes of design thinking at Stanford d.school
MIT, Professional short programs (2017)	Design thinking for business professionals
Harvard Graduate School Executive Education (2017)	Design thinking for business professionals

Figure 11. Document analysis chart

Design thinking is a term that refers to the cognitive processes and skills related to designing such as abductive reasoning, exploring multiple solutions, working within parameters, and evaluating the effectiveness of both form and function (Cross, 2007). Notable names in educational theory and practice, including Dewey (1938), Schon (1973), and Papert (1991), have discussed the concepts espoused in design thinking, though the term was not yet defined until later in the 20th century. Dewey's (1938) theories of experiential education suggest that learning happens through experience with the natural world, through observation, the testing of hypotheses, and interacting with all the senses. He argues that in the traditional method, "Teachers are the

agents through which knowledge and skills are communicated and rules of conduct enforced" and "that which is taught is essentially static" (Dewey, 1938, p. 18). Espousing a more progressive view of education, Dewey promotes an active learning environment that he believed was better-suited for young minds and experiences. By experiencing the physical world and its causes and effects, learners are better able to identify problems and explore multiple solutions to those problems, such as learning about principles of water by experimenting with what types of objects float or sink. In this manner, Dewey suggests that learning happens by observing, doing, making, interacting, and testing cause and effect within the context of the natural environment, which are all aspects of the design process.

A few decades later, Schon would make a similar argument for an experiential education, wherein the teacher is not the conveyor of knowledge from static texts, but rather one who "facilitat[es] learning-by-doing," and acts as a coach alongside novice learners (Waks, 2001, p. 47). In an analysis of Schon's philosophies of design education, Waks (2001) outlines Schon's three tasks of coaching:

1) Dealing (alongside the novices) with the substantive problems of design, via combinations of moves/words, demonstrations/description, in order to convey to novices the ability to deal with similar situations.
2) Particularizing the demonstrations/descriptions to specific —learners—that is, fitting esoteric moves and words into a dialogue with the novices' uncertain movies and words.
3) Maintaining relationships with the novices. These teaching-learning relationships are fraught with problems because the novices can only learn by —doing—but as novices, they cannot yet actually do. The novices thus can be expected to experience feelings of loss of control, vulnerability, and enforced dependence. Therefore, coaches must cope with the predictable negative feelings arising in this predicament. (Waks, 2001, p. 45)

Schon's view of the teacher as coach helps novice learners navigate the problem space, also searching for multiple solutions to problems and determining the parameters of those solutions. Though it is not explicitly taught, the teacher-coach is also modeling empathy through the development and maintaining of relationships, working with the novice students to help move through ambiguous problem areas (Waks, 2001, p. 45). Additionally, according to Waks (2001), Schon's model of teacher-coach is completely at odds with the traditional view of teaching that Dewey (1938) also described, demonstrating that both Dewey's views of experiential education and Schon's views of learners working alongside the teacher to solve "the substantive problems of design" propose that students learn best by doing, in the context of the actual problem or concept (Waks, 2001, p. 45). Both views point towards a view of situated cognition, as demonstrated in the writings of Brown, Collins, and Duguid (1989). These views of learning through experience and observation of the world, working alongside the teacher as a facilitator, using the physical world and its contexts as the learning environment, and identifying and solving problems are all aspects of design thinking and the design process.

The theory of situated cognition also aligns with design thinking and the design process. Lave and Wenger (1991) suggest that members of a community learn because of actively participating in that community, and that knowledge is created by members sharing and applying that knowledge within the situations that develop as the community grows and interacts. Kelley's description of the design process suggests that —learners—or in IDEO's case, —designers—learn about their users by actively observing people and their actions to gain greater understanding of their challenges (Solomon, 2013). Designers' active participation and observation of users allow for empathy and understanding, which in turn lead to greater knowledge of the problem and more information with which to solve problems through design. In Waks' description of Schon (2011), his view of teacher-coach also shares similarities with Lave and Wenger's (1991) theory of

legitimate peripheral participation, where novices learn alongside experts and move towards mastery through apprenticeship and collaboration.

Papert (1980) took experiential learning one step further, arguing that children learn best not just by doing, but by making and creating, both essential elements to design thinking. In *Mindstorms*, Papert (1980) presents a scenario where students become dissociated from learning physics when presented with formulas and equations for memorizing and solving but become immediately connected and engaged when asked to interact with turtles (programmable robots) and represent similar knowledge through programming the turtle to move at different velocities. This expression of learning through making is highlighted in an interview of Kelley, founder of IDEO (Solomon, 2013). In it, he says that making, whether through quick sketching, crude prototyping, or simple media creation, helps the designer work through possible solutions and gives both users and experts an opportunity to offer feedback about the potential design (Solomon, 2013). Both Papert and Kelley suggest that the act of making can help to visualize concepts and tangibly solve problems.

A close reading of each of the documents from the analysis show that major themes begin to emerge across the seven documents from the theoretical approaches category. When compared against one another, the concepts expressed by these authors show similarities and connections across the following categories: making and creating, human-centeredness and empathy towards others, the use of technology, collaboration with partners or community members, learning within a real situation or context, experimenting and revising or refining ideas and theories, demonstrating flexibility or comfort with ambiguity, and using creativity and innovation to solve problems.

Even though multiple voices in educational theory and research have pushed for a more experiential and constructive approach to K12 education over the last century, the educational system has struggled to embrace these philosophies in the day-to-day interactions in schools. At the turn of the 21st century, NCLB, in an effort to see increased academic achievement in schools

across the country, put all its eggs in the high-stakes testing basket. What resulted was an overwhelming move to "teach to the test," essentially learning by memorization, and forego any chance of learning by doing or making. Research indicates that time was taken away from non-tested subjects such as geography, art, and music and instead was allocated primarily towards content included on the standardized tests (Dee, 2010). Negative effects included low teacher morale and teacher stress (Azzam et al., 2006). In the United States, the post-NCLB era has resulted in a widespread look at how students are instructed and assessed. Standards have been revised, overhauled, and completely rewritten in an attempt to move away from the high-stakes testing era of the early 2000s. In the last five years, K12 education has seen the introduction or revision of the CCSS, NextGen Science Standards, National Core Arts Standards, ISTE Standards, and the P21 Framework.

The CCSS, the most comprehensive of the four areas, are intended to guide instruction in mathematics and overall literacy in reading, writing, speaking, listening, language, and literacy across all content areas. Major key shifts in the areas of literacy are meant to focus on college and career readiness, appropriate and innovative use of technology for communications, and deeper development of skills in critical thinking, problem-solving, and analysis (Common Core Standards, 2010). Additionally, the eight mathematical practices outlined in the standards look at what students should be demonstrating through their math skills, including cross-disciplinary practices such as "mak[ing] sense of problems and persevere in solving them," "reason abstractly and quantitatively," and "use appropriate tools strategically and attend to precision" (Common Core Standards, 2010). These skills also comprise important aspects of design thinking, which requires one to identify problems, use appropriate tools to understand the problem and develop prototypes for potential solutions, and generate possible solutions through brainstorming and research.

In 2013, the NextGen Science Standards were published, reframing science education in K12 schools across the United States. Just as with the CCSS, the NGSS were redesigned to

encompass the most recent research in science education and promote critical thinking, cross-disciplinary connections, and STEM concepts. Prior to the development of the standards themselves, the National Research Council developed the Framework for K12 Science Education, which connects three dimensions of science education: practices (behaviors in which scientists engage), disciplinary core ideas, and cross-cutting concepts (concepts that link different scientific domains). The NGSS information website refers to experiential learning, claiming that these new standards "enabl[e] students to learn science by doing science" (NGSS Lead States, 2013). This phrase directly references viewpoints held by Dewey (1938), Schon (1973), and Papert (1991), that students should learn by doing.

At the same time, the fine arts standards received an overhaul, which led to the introduction of the National Core Arts Standards in 2013. Combining the disciplines of dance, media arts, music, theater, and visual arts, the NCAS promote four areas of artistic education: creating, performing/presenting/producing, responding, and connecting. Eleven anchor standards divided across the four practices create the newly revised framework for arts education in K12. These standards were also developed to work in collaboration with the CCSS, emphasizing similar themes of critical thinking, analytical skills, and adding importance to the value of creativity and its role in culture and history (National Core Arts Standards, 2014). The new arts standards are also notably the first time design has been included in any version of national standards, in any content area. In these standards, students are asked to engage in the design process for the purposes of creating art in a variety of media, including the utilization of technology for innovative and creative communications.

Nearly two decades ago, the ISTE standards were created to help students solve complex problems using technology. While digital tools and technology are at the forefront of the ISTE standards, they are designed to empower students to do more than just use computers: the ISTE standards encourage students to specifically use the design process for solving problems,

identifying the ability to solve problems, testing potential solutions, collaborating with others, and communicating findings in a clear manner. What is unique about the ISTE standards, however, is not just the overall vision to leverage technology for creativity and innovation, but the commitment to educate all K12 stakeholders by including standards for educators, administrators, computer science teachers, and instructional coaches (ISTE, 2016).

The last major shift in K12 education in the last five years includes the P21 Framework, developed by the Partnership for 21st Century Learning, an organization made up of major industry partners such as Ford, the Walt Disney Company, Crayola, Fisher Price, and Lego Education; educational partners including the American Federation of Teachers, The Goddard School, National Board; non-profit organizations such as PBS, American Camp Association; and partnering states who have committed to embedding 21st century skills into standards and professional development (Partnership for 21st Century Learning, 2012). The Framework for 21st Century Skills includes four main interconnected areas of learning: life and career skills; key subjects (including reading, writing math, and 21st century themes); information, media, and technology skills; and learning and innovation skills (critical thinking, communication, collaboration, and creativity). All four of these areas are supported by standards and assessment, curriculum and instruction, professional development, and learning environments. It is worth noting that in examining the standards, frameworks, and recommendations across these five areas, the teaching of design processes only appears in the visual arts segment of the National Core Arts Standards and in the ISTE standards for students.

Unlike the United States, design standards have been in place for at least half a century in countries around the world. Design professor Archer (2005) began advocating for design education as its own subject in the 1960s, and the Coldstream Report of 1960 led to the establishment of design as a field of study in Great Britain (Archer et al, 2005). As early as the 1960s, art and design standards became a part of the national curriculum, and design and technology standards

were introduced in the late 1980s. Great Britain boasts the earliest implementation of design education standards for primary and secondary students, including design in both Art and Design as well as Design and Technology standards. Within the Art and Design strand, students are expected to demonstrate proficiency in producing creative work; developing user-centered, innovative, and functional products; and honing skills in identifying and solving problems. Students are also expected to know how to use a variety of analog and digital tools for making and creating, all with a focus on craftsmanship and aesthetics. Within the Design and Technology strand, students should be able to demonstrate mathematical modeling, knowledge of machinery and tools necessary for making, and the ability to test, evaluate, and refine ideas. Students also need to have systems knowledge of mechanical systems, engineering, computing, and electronics for the purposes of designing effective solutions.

More recently, Singapore adopted standards in design education to promote greater innovation and production for its economy. Secondary students are required to take courses in design and technology and are expected to develop an awareness of design in the made-world, exhibit an appreciation and understanding of function, aesthetics, and technology, and have experience with design thinking and communication skills. They also need to have the ability to think creatively, make creative decisions, and pay special attention to sustainability, safety, and the appropriate use of tools and materials. In the last decade, Singapore has seen a significant increase in the creative fields, ranking as high as fifth best city for attracting global creative talent (Fen, 2016).

As school systems around the world continue to recognize the value and impact of design thinking and processes on young learners, major industries are restructuring so that they incorporate design thinking into their business models. While IDEO has long been hailed as the industry standard for design thinking (they ushered the term into common vernacular), universities are beginning to expand their design offerings to include courses in design thinking; there has even

been the appearance of a Master of Fine Arts in design thinking. Schools including Stanford, MIT, and Harvard have developed programs to introduce students and business professionals to the principles of design thinking and the design process. At Stanford, the Hasso Plattner School of Design is a design thinking institute, founded by IDEO founder David Kelley, along with several other professors. The institute offers courses for Stanford University students as well as programs for business executives looking to add creativity and innovation to their businesses. Both MIT and Harvard offer courses in design thinking and innovation through their professional programs as well as through their edX MOOC programs.

Over the last few years, IBM has been going through a major shift to incorporate design and design thinking to their business model, developing their own design thinking guidelines in hopes of becoming a global leader in design (Stinson, 2016).

In surveying the worldwide landscape of design thinking impact, it would seem as though all roads lead to IDEO. From kindergarten to industry to non-governmental organizations, IDEO's impact is pervasive, and their model is the standard by which many design thinking models are measured (O'Dwyer, 2018). As this research will continue to demonstrate, collaboration with IDEO often leads to successful design thinking implementation. After surveying and synthesizing data from the four domains of educational theory and research, K12 standards in the United States, K12 design standards worldwide, and industry and professional development, multiple key themes and connections began to emerge. Following the identification of key concepts across the four domains, they were coded for common themes. Figure 12 details the most common and defining themes from the analysis.

Key Concepts and Connections of Design Thinking in K12 Education

CONCEPT	DEFINITION	DOMAIN
MAKING/CREATING	Using a variety of tools to engage in the creation physical and digital objects, sketches, media, and prototypes	USK12, Global, Industry, Theory
HUMAN-CENTERED/ EMPATHY	Focus on the needs of others; understanding how others perceive, interact, and engage with their world	Global, Industry, Theory
TECHNOLOGY	Learning new technology tools; using technology to innovate new solutions	USK12, Global, Industry, Theory
COLLABORATION	Work with others from diverse backgrounds	USK12, Industry, Theory
SITUATIONAL/CONTEXTUAL	Learning experiences occur either in part or entirely in the real world and potentially have real world impact	USK12, Industry, Theory
EXPERIMENT/REFINE/REVISE	Iterative cycles allow for feedback, revision of ideas, and working through multiple possibilities	USK12, Global, Industry, Theory
IDENTIFY AND SOLVE PROBLEMS	Learners use prior knowledge, constructed knowledge, and knowledge shared by collaborators to identify problems and develop solutions	USK12, Global, Industry
FLEXIBILITY/AMBIGUITY	Experiences are not fully defined or laid out, but rather have elements of unknowns and require learners to make adjustments	USK12, Industry, Theory
CREATIVITY/INNOVATION	The process requires learners to use creative problem solving and develop both novel and useful solutions	USK12, Global, Industry, Theory

Figure 12. Key concepts and connections of design thinking in K12 education

From the nine concepts in Figure 12, the next step was to determine how these connections could be developed into guiding principles for use by educators, pre-service teacher education programs, and curriculum designers. Rather than using each theme for its own guiding principle, seven principles were established. Technology was removed as a guiding principle, as Papert

would suggest it is only a tool for constructing knowledge, not a principle for guiding behavior. Additionally, the concepts of Identify and Solve Problems and Situational/Contextual were combined into a single statement to reflect the concept that all problems should be identified and placed within a real-world context. These guiding principles were also used to facilitate and develop communities of practice focused on K12 design thinking and learning in answering the next two research questions. The guiding principles in Figure 13 are designed to assist K12 educators in preparing themselves and their students to engage in the design process.

GUIDING PRINCIPLES FOR TEACHING DESIGN THINKING
1. Identify and solve relevant, meaningful problems in the real world, not the school world
2. Collaborate dynamically and frequently with colleagues and professionals outside the field to get the most out of everyone's collective knowledge
3. Develop a laser-like focus on the needs and perspectives of others (this includes students)
4. Engage in the physical acts of making, sketching, and media creation for quick, iterative visualization and feedback
5. Experiment, revise, refine... repeat!
6. Be willing to act flexibly and work in places of unknowns and ambiguities
7. Approach problem solving and brainstorming with playfulness and without judgment in order to increase creativity and innovation

Figure 13. Guiding principles for teaching design thinking

These statements are intentionally written using informal and playful language to engage educators in a more conversational and colloquial tone as opposed to more theoretical and lofty language. As the principles' intended purpose is to encourage participation with the design process, they should be accessible to a wide variety of educators, from those who are just learning about the concepts of design thinking to those who are more experienced with its concepts and processes. Establishing these seven guiding principles serves to answer the first research question, which was what core guiding principles of design thinking are most important, relevant, and feasible in K12 education? This question demonstrated that document analysis served useful and productive for establishing guiding principles. The analysis provided four categories of comparison including theoretical frameworks (most important), industry-standard applications of design (most relevant), and national and global K12 standards (most feasible). From there, nine common concepts were identified, and condensed into the seven guiding principles described above.

Research Question 2

RQ2: What are the best methods for K12 educators to learn and share knowledge about teaching design thinking?

RQ2 addresses multiple elements of how educators are currently learning and sharing knowledge about design thinking including an analysis of existing methods as well as the implementation of three iterations of methods for sharing and learning about design thinking with three different populations, Groups 1, 2, and 3 (G1, G2, and G3, respectively). To finalize the Research and Plan phases of the action research and design processes, the first segment of this question seeks to examine the current scope and use of educator networks and collaboration tools.

When introduced to new content, policy, protocols, and pedagogy, teachers often engage in professional development to acquire new skills. Teacher professional development has challenges, though methods continue to evolve. With technology and social media pervading 21st century

education, educators have increasing amounts of tools, processes, and methods to choose from when engaging in professional learning. This research question seeks to understand the scope of current design thinking and learning-based networks available to teachers, the tools teachers are using to learn about design thinking and learning, and the most effective methods to help teach educators to learn how to use design across content areas. While many educators are using social media to share media, few online communities exist; if groups exist within Facebook, LinkedIn, or Twitter, they are generally linked to larger communities outside of K12 education. At the outset of this study, Facebook had several inactive groups on the topic of design thinking in K12 education, LinkedIn had a few K12 design thinking-related groups, and Twitter had a wide variety of K12 design thinking hashtags, but few are part of established communities. Figure 14 illustrates the initial cycle of the design process, beginning with the Research phase.

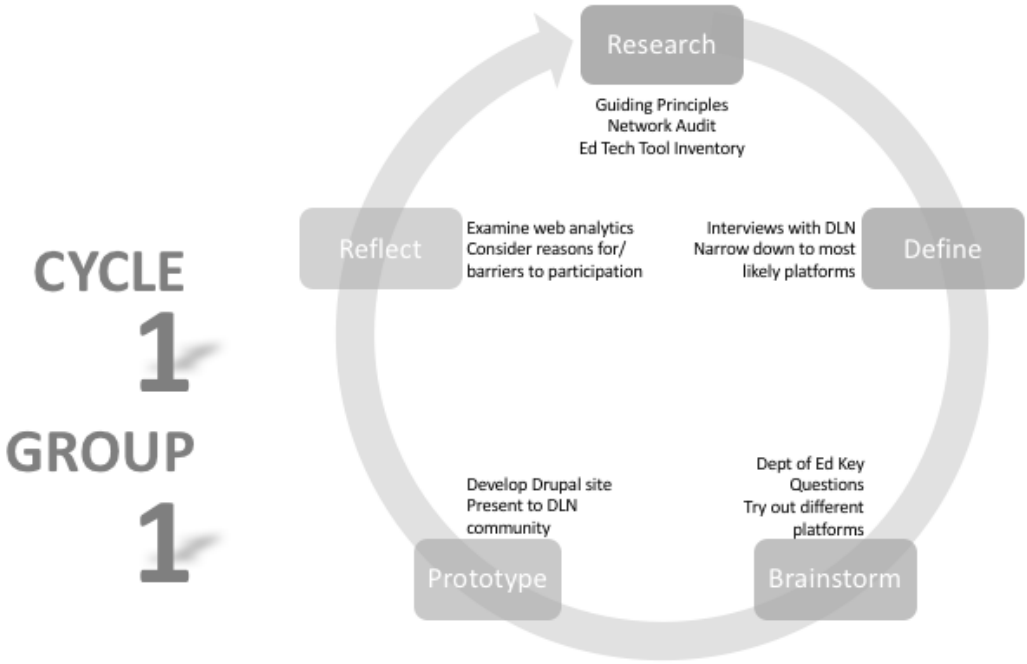

Figure 14. Implementation of Cycle 1

The first group of participants in this research study had begun discussions about creating an online community centered on design thinking. However, they had little direction in terms of

what types of communities were already available and what platforms and structures were most effective in facilitating the type of community they desired to create. To collect data for this question, the first step was examining the current scope of online communities and networks centered on design thinking for educators as well as surveying the most effective collaborative tools to facilitate successful communities.

To begin with, several criteria were established to determine what constituted an educator network. First, the network had to include community features, such as interaction between members (not just a single individual/organization posting in a group), opportunities to meet virtually or physically, or the ability to give and receive feedback. Second, the network had to focus primarily on K12 education and its involvement with the design thinking process. Many communities exist, both physical and virtual, that are related to design thinking, as it is a prominent topic in industry right now, but industry applications are much different from K12 applications, and the primary purpose of this study is to understand the advancement of design thinking in K12 education. Third, the community had to be easily accessible; that is, a user should be able to find and participate in the community with a minimum of barriers. For example, the group should be easily found with local or Internet searches and not require fees or extensive background information for permission to observe and participate. With these three criteria in mind, several online communities emerged as venues for K12 educators to network and advance design education. The following eight communities offered varying degrees of community support for the design process in K12 education:

- Adobe Education Exchange
- American Institute of Architects
- American Institute of Graphic Artists
- Makerspace for Education
- Nueva School

- Redesign Challenge
- Stanford K12 Lab Network
- Teachers Guild

Overview of Networks

The Adobe Education Exchange, created by Adobe and designed for users and educators of the Adobe creative suite, offers four main areas of interaction: Learn, Teach, Discuss, and Connect. While someone without an account can view some of the material on the community, creating an account allows access to participation in the community and the ability to view and download all available resources. Within the Learn feature, users can access online tutorials, self-paced workshops, information about live events, collaborative courses, professional development opportunities, and Adobe Trainer certification. The Teach feature provides an extensive and robust search engine that allows educators to filter by Adobe product, subject area, and grade level to find free and appropriate lesson plans. Lesson plans are uploaded by Adobe Education Exchange members and can range in depth and quantity of materials, though all content on the site can be rated, liked, and shared by members. The Discuss section allows users to participate in and generate discussions with the Adobe EdEx community and includes social media aspects such as ratings, comments, and sharing. The Connect feature allows users to follow and be followed by community members. Other features include viewing members' teaching resources, expertise, and community activity.

In addition to these multiple and extensive resources for K12 educators, the Adobe Education Exchange offers elements of gamification including a point system and badging; personalized dashboard including learning and teaching modules based on recommendations from previous interactions and profile as well as recommended members with whom to connect and an extensive member directory of almost 400,000 participants. While every interaction on this site is

not focused on the design process, the process is incorporated into many of the lesson plans and resources.

The professional design organizations of the American Institute of Architects (AIA) and the American Institute of Graphic Artists (AIGA) both attempt to connect with K12 educators. The AIA website includes a discussion forum and downloadable documents focused on outreach to schools, and while the site offers blog and events features, none were available. The forum noted 100 members in the community. The AIGA website includes contact information for local chapters to get involved in their communities and case studies of design in K12 education. While the AIGA website does not quite meet the interactive criteria for inclusion in this selection, it does offer any participant the opportunity to share stories and case studies of design. Other than AIGA and AIA, there are no other professional organizations making any attempt to connect with K12 educators, at least in an easily accessible manner. In 2012, the Industrial Design Society of America had active design challenges for K12 students and teachers, but those have since ceased, and no activity related to K12 education is present on their site.

Makerspace for Education is an online community hosted through Weebly and created by several Canadian teachers to share information about creating makerspaces and using makerspace lessons in the K12 classroom. The site includes a statement of purpose (the "manifesto"), blog posts by the community creators, a gallery of makerspaces submitted by the site creators, lesson plans available for download, a place to submit lesson plans for review to the site administrators, and a wiki page with an invitation to collaborate. At the time of this writing, the invitation link does not work. The site appears to be an attempt at creating an online community of practice, with extensive resources for reaching out to and providing information for teachers to collaborate and create effective makerspace environments. The site also houses what appears to be a literature review of major theories that support makerspace education, including pages on the design thinking process, Seymour Papert's big ideas, and constructivism and constructionism. Thought

and planning appear to have been behind the creation of this site, although the interaction seems to be limited by the lack of ongoing involvement and engagement of the site creators, making the community more of a static resource and less of an ongoing collaboration.

The Nueva Design Thinking Institute is a summer workshop program run by the Nueva School in the San Francisco, California area. While the Nueva School does host a website with resources for teachers looking to incorporate design thinking into their classrooms, the primary focus of Nueva's outreach to teachers is through on-site conferences. Experiences include the Innovative Learning Conference and the Design Thinking Institute. Nueva's reputation comes from its track record of teaching design thinking to K12 students as well as its close partnerships with IDEO and Stanford's d.school, both of which are global leaders in the design thinking movement. Though this organization's accessibility is limited to those in the school's geographic area, there are numerous opportunities on the site for grants to aid in travel to the location.

Developed by a collaboration between Seattle, Washington design firm Artefact and the Bill and Melinda Gates Foundation, the Redesign Challenge is an interactive, crowd-sourced, design thinking workshop focused on K12 education. The site features an online platform dedicated to using the design process to pose and solve problems in education, with teacher contributions in the form of suggestions, comments, and voting. While the Redesign Challenge appears to be an ongoing system of posing important challenges in teaching, the post dates suggest that the site was mostly active during 2015, and activity has since been suspended. The format of the community appears highly interactive, allowing members to post ideas, give feedback, and share content through social media. Additionally, the site features recipes that include how-to's for implementing some of the crowd-sourced solutions. The recipes include visuals, step-by-step directions, evidence of success, and tips for problem solving, as well as guiding principles such as the acceptance of community guidelines and transparency and openness among members. Just as in the Makerspace for Education community, this site has many resources to help teachers learn

about the design process and incorporate some of the solutions into their classrooms, but the lack of updated information and interaction do not give teachers the experience of walking through the process with others, which is what the site's original intention claims.

One of the oldest and most well-known resources for design thinking in K12 education, the Stanford K12 Lab Network, provides extensive resources on their wiki page for teachers looking to introduce design thinking into their classrooms and professional development. The wiki contains notes, videos, links to Google docs, and lesson plans to walk teachers through the process, though viewers may not add anything to the wiki. Like the Nueva Institute, workshops for the Lab Network are all hosted on-site and require travel to the San Francisco area to participate. They also feature an email newsletter, Facebook group, and Twitter chat on Wednesday evenings, using the #dtk12chat tag, which is active at the time of this writing. The Twitter chat began in 2012 and has since hosted more than 100 weekly chats with over 14,000 tweets containing the tag.

Last is the Teachers Guild, a professional community created and run by a collaborative effort between members of IDEO and Riverdale Country School. The Teachers Guild website features an interactive design process experience where users can collaborate on problems posed by the community, suggest ideas, make comments and like content, and view and contribute to solutions. The format is like the Redesign Challenge, although this site appears to be ongoing and has significantly more content than any other website listed here. The site also includes downloadable resources, and most importantly, the Design Thinking for Educators Toolkit, created by IDEO and Riverdale Country School. This community is distinct from all other communities in that it actively teaches how to use the design process through its user-generated problems and solutions, provides extensive resources from educators in the field, and connects users to coaches (experienced teachers and professionals using the design process) who can help walk individuals through the process both digitally and physically depending on users' locations and organizational partners.

Teachers Guild features multimedia experiences, including video, social media elements, private messaging, and gamification elements. The site also includes timelines for each challenge so users can see what stage of the process each challenge is in and the time left for contributing to the challenge. Additionally, for each step in the design process, the site includes bullet points for how to implement that part of the challenge, resources for downloading to aid implementation, and contact information to connect with a coach for more personalized help in the process. Colorful visuals guide the user in the process. When challenges are completed, solutions are posted and include photos from the solution, feedback from teachers who implemented that solution, and ideas for revision moving forward.

Looking at all eight communities collectively, several trends begin to emerge that help organize the types of networks available, how they are accessed, how they were created, and ultimately, how successful they are in terms of connecting educators and advancing design thinking in K12 education. To begin with, three formats were available with these eight networks: digital, physical, and blended. Figure 15 summarizes how these networks are accessed.

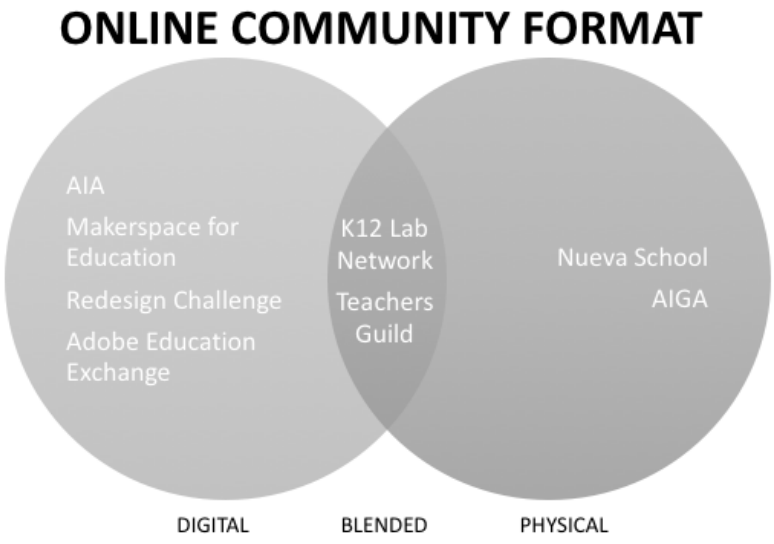

Figure 15. Comparison of online community format

Additionally, each network was varied in its authors and their relation to K12 education, whether created by industry, education, or a collaboration between the two. Figure 16 illustrates the primary creators for each network.

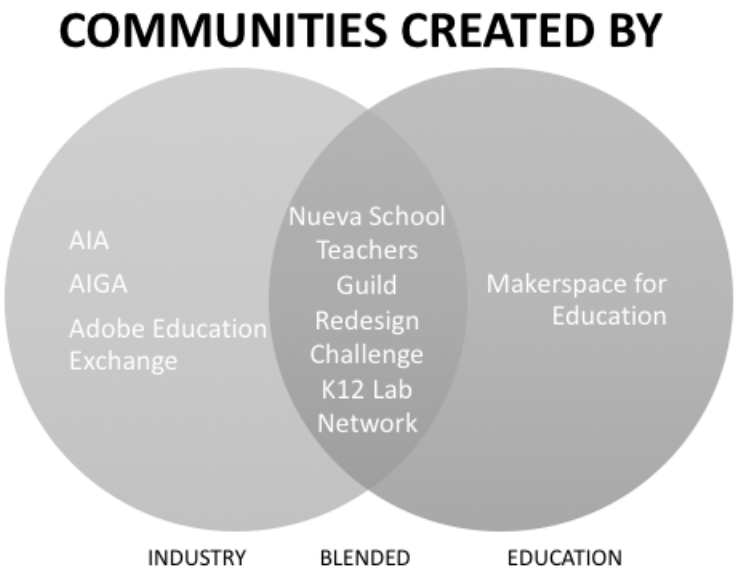

Figure 16. Comparison of online community creators

When comparing the online communities evaluated above, the most robust communities and interactions occurred when industry and education collaborated. While the professional organizations' networks attempt to connect with K12, they often fall short due to contributing factors, including a lack of understanding about K12 curriculum and lack of strong emphasis at a national level on connecting and collaborating with K12 schools. The success and failure of these networks is dependent upon the leadership within local chapters. The exception in the industry category is Adobe, though the company has a significant global investment in education and their products are widely used in K12 media curricula. Additionally, Adobe's product focuses entirely on digital media and design, so it would seem both sensible and feasible for this company to have a large, active community committed to teaching and learning digital design.

The lone community created by educators, Makerspace for Education, suffers due to a lack of support and site maintenance. The content available on the site is useful for educators looking to use the design process and makerspace projects, but as countless studies show, educators can be overworked and have little free time available to devote to extracurricular projects such as maintaining an active online community. This site serves as an example of the importance of outside resources in helping to administer and maintain the community.

The three strongest communities in this evaluation all have one common denominator, IDEO. The Teachers Guild, Nueva Design Thinking Institute, and the Stanford K12 Lab Network all boast strong collaborations with the global leader in design thinking, IDEO. Each community is different: Nueva Institute is a physically-located entity, the Stanford K12 Lab Network is a static website with extensive resources, and the Teachers Guild is predominately digital. These differences also suggest that successful communities are not dependent upon physical interaction, though blended communities do often have increased benefits (Matzat, 2012).

Overview of Collaborative Tools

For teachers, the library of educational technology tools might seem endless and overwhelming, and some organizations have begun creating resources to assist teachers in making the choice of which tools to use and when. EdSurge, a company that curates educational technology resources, has created a playbook to help teachers understand the needs of their classroom, their instructional pedagogy, and how to leverage those aspects to choose the right tools for their classroom (EdSurge, 2016).

To determine which tools would be the best technologies to facilitate the K12 design thinking conversation, several criteria were established to narrow down the abundant pool of resources. First, the tool should provide opportunity for collaboration and community, whether through shareable documents and resources, real-time connectedness capabilities, social media features, or environments that allow multiple people to contribute. Second, the tool should have a

shallow learning curve to allow teachers with limited time to enter the experience and still encourage participation. Third, the tool should not be cost-prohibitive to either the educator or educator's employer. Using these three criteria, some of the most popular tools used by educators were collected and evaluated based on their collaboration potential. While Figure 17 is certainly not exhaustive, the document lists tools teachers currently use for networking and collaborating in the digital world and the many features offered by those tools.

	Activity Stream	Blogging	Calendar	Collaboration	Commenting	Customization	Forums and Discussions	Groups Capabilities	Connect w members	Learning Mgmt System	Microblogging	Mobile App	Notifications	Plugins	Polls/Quizzes	Private Messaging	Project Management	Public/Private	Resource Curating	Resource Sharing	Short Group Messaging	Video Chat	Webinars
Adobe Connect				x		x					x	x					x				x	x	
Asana	x		x	x	x				x			x	x			x	x		x	x			
Basecamp	x		x	x	x		x	x	x				x			x	x		x				
Blackboard			x	x		x	x	x	x	x		x	x	x	x	x	x		x				
Canvas	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x		x				
Cisco WebEx				x												x					x	x	x
Diigo				x	x			x	x									x	x				
Dropbox				x	x							x	x				x						
Drupal	x	x	x	x	x	x	x	x	x				x	x	x	x		x	x	x	x		
Edmodo	x		x	x	x		x	x	x	x		x	x		x	x	x	x		x			
Flipboard				x	x	x						x	x					x	x	x			
Google Apps		x	x	x			x	x	x			x	x			x	x	x		x		x	x
Hangouts				x								x	x			x						x	
Hive	x		x	x	x			x	x			x	x			x	x	x	x	x	x		
Keep				x	x							x					x	x	x				
Padlet		x		x	x	x						x					x	x	x				
Pinterest				x	x				x			x					x	x					
Schoology	x		x	x	x		x	x	x	x		x	x		x	x	x		x				
Skype				x								x	x			x						x	
Slack	x		x	x	x			x	x			x	x			x	x	x	x	x	x		
Trello	x		x	x	x			x	x			x	x			x	x	x	x	x			
Twitter	x			x	x				x		x	x	x			x		x	x	x	x		
Wikispaces		x		x	x										x			x	x	x			
Wordpress	x	x	x	x	x	x	x	x	x				x	x	x	x		x	x	x	x		
Yammer	x			x	x		x		x		x	x	x			x		x		x			
Zoom				x												x					x	x	x

Figure 17. Collaborative educational technology tool resource matrix

After generating this extensive list of possible tools and resources, five stakeholders participated in informal interviews to determine the direction of the online community. The primary organizer of the non-profit design learning group was interested in a community that offered greater functionality than LinkedIn, where she had been hosting a Design Thinking Working Group. While the LinkedIn group offered features such as following one another, viewing profiles, sharing media, and direct messaging, it did not offer the option to create collaborative documents, store resources in shared folders, and contribute to a shared calendar. Each participant requested the ability to store documents in shared folders and work on collaborative documents together. While Google Apps seemed to satisfy some of these requests, two interviewees expressed concern about privacy with the Google platform. One participant mentioned that she wanted to be able to query the group and receive instant feedback about topics such as lesson plan ideas and collaborative problem solving. This type of request would require the ability to turn on notifications for mobile devices. Another participant said his ideal experience with the community would be to see "educators connected from around the world, learning with and from one another to create global design challenges."

After reviewing the responses and balancing the requests with the network audit, collaborative tool survey, Guiding Principles established from the first research question, and the learning curve of available platforms, four platforms were chosen as the most likely options for the online community. To fully explore the framework and priorities for the online community, the design team continued the development process by utilizing many of the "Key Questions for Community Designers" as outlined in the U.S. Department of Education's report on designing online communities of practice, resulting in the following responses.

Key Questions for Community Designers

Community focus. The purpose of this online community is to bring together K12 educators and members of the design community to learn from one another, share resources related

to teaching the design process, make connections with like-minded individuals, and create new content for the purposes of teaching the design process in K12. The core audience for this site is K12 educators, although input and expertise from higher education and design professionals would be invited. Additionally, the desire is for the audience to be global. Users will interact asynchronously with one another primarily through the digital forum, though opportunities for physical meet-ups including annual conferences and regional activities could be incorporated into the network. For example, the Design Learning Network (DLN) has sponsored Design Symposiums for the last several years, where educators learn and share how to implement a variety of design-related pedagogies. The hope is that by providing a digital space for design-minded K12 educators, it will be easy to connect with and support one another in implementing projects, challenges, and pedagogy that are not necessarily at the forefront of district directives. This community is differentiated from others in that K12 design education in the United States is still a relatively new topic, though it is quickly gaining ground. There are few current networks, both digital and physical, where teachers can collaborate on design process-related topics.

Leadership and stakeholders. Currently the leadership for the online community includes the director of a non-profit organization devoted to engaging students and teachers in creative problem-solving, as well as the researcher, who is also a member of the non-profit, and two additional leaders within the non-profit community. As the community emerges, teacher leaders can be identified as leaders in the online community. The director of the non-profit organization will act as a co-designer of the community, based on her background in design and curriculum, and the researcher will act as co-designer and community developer, based on her experience in teaching middle school, developing design-based curriculum, and extensive background with educational technology. The initial participants of the community will include educators who have been connected directly or indirectly with the organization and the National Arts Education

Association Design Issues Group (DIG). As the community evolves, participants will have opportunities to provide feedback in order to improve the experience.

Role of resources. Resources will be both shared and created through interaction with the online community. The most useful resources for the community will include documents such as lesson plans, articles related to teaching and design, discussion forums surrounding implementation of design-based pedagogy, media files, polling, and collaborative spaces such as wikis. All members of the community will be encouraged to contribute resources they find helpful in teaching design process across the curriculum. The site will include several different forums for sharing and connecting, including discussion threads, public and private groups, polls, blogs, wikis, and shared calendars. At this point, there are no plans for vetting resources, aside from establishing overall norms for interaction within the community. Social functions (such as liking posts, following, and subscribing) will assist in determining which resources are highly valuable.

Public vs private. The proposed site platform should include options for both public and private participation, including the ability to join private groups, determine what content will remain public versus private, and the ability to view or participate depending on the user's status. The site administrator will have authority to grant user status including active user, administrator, or moderator status, which allows administrator-approved users to create and moderate groups and set content as public or private. By making some general content viewable to everyone, potential users will have the opportunity to preview the community. They will also see that membership is required to actively participate in the community, giving the group a modicum of exclusivity and privacy.

Adapting technology. The community platform should have the ability to utilize as many technology features as possible, including viewing, downloading, adding, and generating content; providing collaboration space for multiple users to work in a single digital space; making connections with other individual users; polling users to gather data; creating and sharing events;

and using social media features such as liking, following, commenting, private messaging, subscribing, and notifications. These specific features will allow users to collaborate on projects, identify those ideas they find valuable, share content with one another, and manage projects together, all things which are important when creating and sharing professional content. The use of the Drupal platform (one possible option for the community network) could potentially alienate teachers who prefer not to use technology for various reasons (not comfortable learning new tools, wary of having too much online presence, or limited time to devote to additional activities whether virtual or physical). The hope is that those individuals seeking community and support in implementing the design process will overlook some of those reasons and still participate. The expressed need for such a community suggests that this will be the case. Additionally, the use of collaborative technology might open doors to even greater cross-geography connections and allow teachers to do more in their classrooms than they could without access to the online community. Currently there is little to no budget, which has forced the design team to look at cost-friendly platforms. The design team and non-profit organization have enough funding to support owning a domain name and hosting the site for a small amount of traffic (up to 10,000 pageviews per month). Should the site warrant it, the budget can accommodate more traffic, but plans are to start small in the beginning to pilot the community. Drupal and Wordpress have emerged as strong candidates for the online community; however, there is a slight learning curve for new users for both platforms. The features are such that the terminology should be like other types of familiar online communities. A steeper learning curve may come for the site administrator and could potentially require professional consultation and intervention, depending on how comfortable the site administrator is with using a platform like Drupal or Wordpress. Time for new users should be limited in terms of learning how to interact within the community. The time needed for managers and site administrators will vary depending on previous web development experience. For this community, some additional assistance will be needed for troubleshooting. When the technology

does not work correctly, it will be important to have an expert on hand to help troubleshoot. In the moment, just as in a physical classroom, the site administrator can communicate quickly to let users know what might be causing problems. Being transparent with technical issues could potentially help in building trust in the individuals managing the community.

Member recruitment. The community will be advertised to specific audiences, including those who have attended design symposiums, members of the NAEA DIG community, and colleagues within the immediate professional circles of site stakeholders. The hope is that these individuals have already demonstrated a heightened interest in exploring the design process in the classroom. As far as converting users into members, there will be multiple ways to engage in the community. Incorporating physical meet-ups based on geography can help educators cross each other's paths. The community will also be populated with content including discussion-starters, polls, groups centered on events and workshops partnering with the organization, and lesson plans available for download to jump-start engagement upon entering the site. Research in communities of practice suggests that mentors within the community will invite others to join and teach them how to become active members. Due to the group capabilities of the chosen platforms as well as the narrowly defined audience for this community, the potential size is not anticipated to be overwhelmingly large. Beginning with a small, actively engaged community would help gain the critical mass necessary to sustain the community. A group as small as 20 or as large as possibly 200 should be sustainable with the site platform and human resources available to maintain the site.

Upon completing this document and exploring multiple online community options, this research led to the selection of four main platforms: Google apps (separate from the GAFE features), WordPress, Drupal, and Edmodo. The collaborative and connected nature of all four platforms could also allow for the implementation of the Guiding Principles, albeit virtually. These four tools were then demonstrated extensively by the primary stakeholders. Based on overall

capabilities, learning curve, availability, and cost, the design team settled on the Drupal platform. Stakeholders and an outside expert in the Drupal platform worked together to create a prototype of an online community, aptly named Teach by Design (see Figure 18).

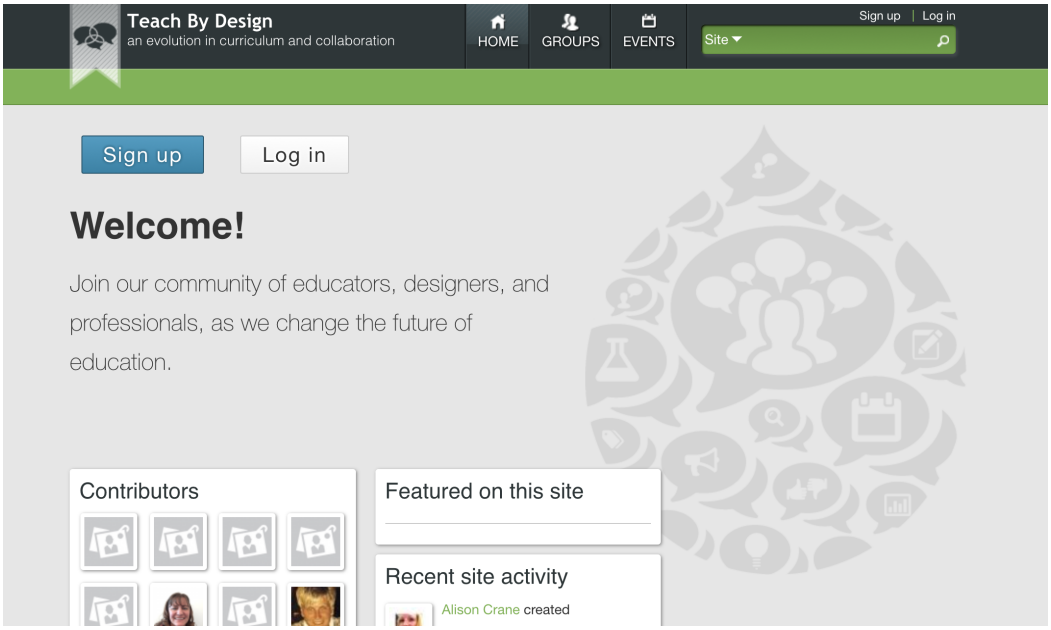

Figure 18. Landing page of Teach by Design community

The prototype included samples of each content type, how they could be used in context with a variety of activities, and several examples of how new users could interact with content and with one another (see Figure 19).

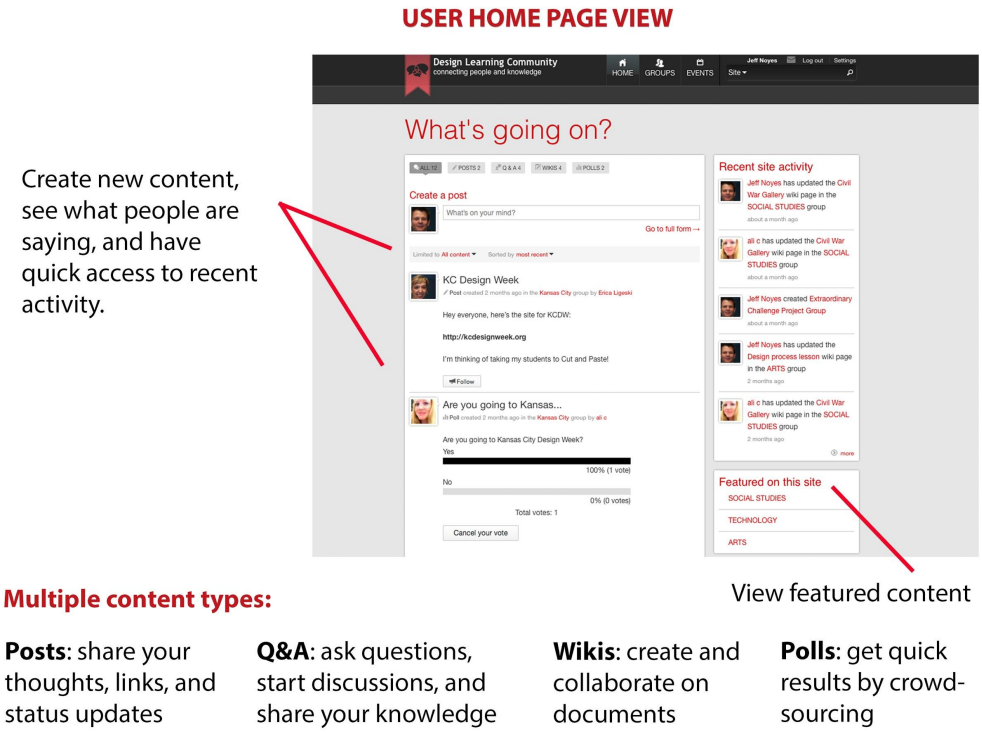

Figure 19. Diagram of user home page view

Once the community was developed, it was presented at several conferences where members of the organization and NAEA DIG groups were in attendance. Initially, several members created accounts for the site, but no activity occurred past that. Once the members had gone back to their home states, there was still no activity on the site, and communication with the members became increasingly difficult. Leaders of the non-profit community also struggled to engage members once the physical interactions ceased. Additionally, with the conclusion of the school term for most members, interest waned. Technical difficulties with the site caused it to go dormant for a few weeks, and critical mass was lost at that point. There was no recorded activity on the website.

This concluded the observe phase of the first cycle of the process. Though a survey had been developed regarding the use of the online community, the researcher no longer had access to the members of the first group; therefore, no data was collected about the lack of participation. To

test the effectiveness of the website again, the researcher was able to connect with a second group of K12 art teachers, Group 2, who were in the middle of a district shift towards more project and problem-based learning, as well as broad training in concepts of design thinking (see Figure 20).

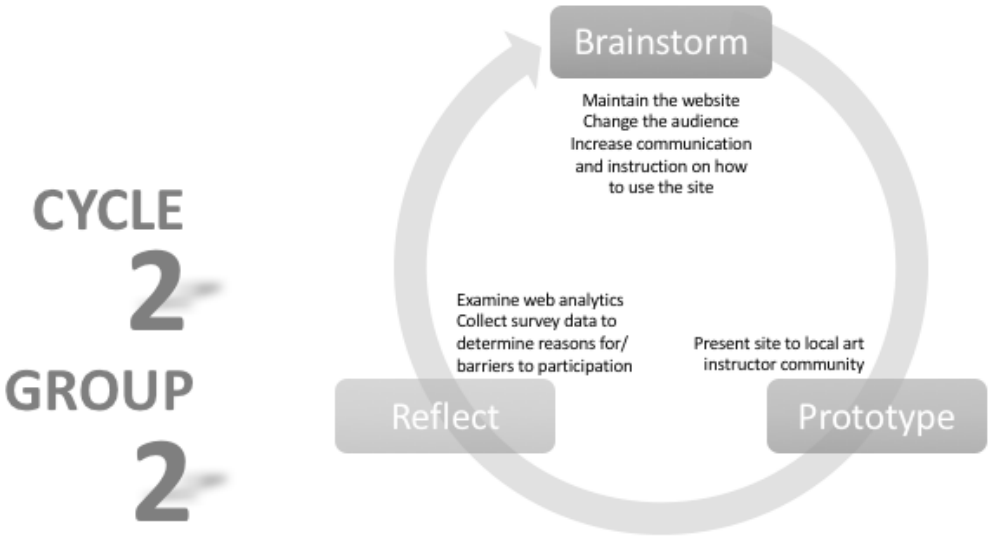

Figure 20. Implementation of Cycle 2

Several changes were made to the presentation and communication of the website to overcome some of the perceived challenges with the first group, including more specific instructions on how to access the site and a clearer definition of the purpose and vision for the collaborative nature of the community. This was expressed in the introductory slide presentation as well as in conversations with individual instructors who expressed additional interest in the site.

This group was comprised of a selection of 37 K12 art teachers from a single suburban school district, of which the researcher is a member. At the outset of this study, this group of educators identified limited familiarity with the design process though many had not training using it in the K12 art room. Though this group had not expressed a specific need for an online community, members had indicated in questionnaire results that they had a desire for resources including exemplar lesson plans for implementing the design process, as outlined in Figure 21. It

should also be noted that zero questionnaire respondents said technology would be helpful in supporting understanding and implementation of the design process.

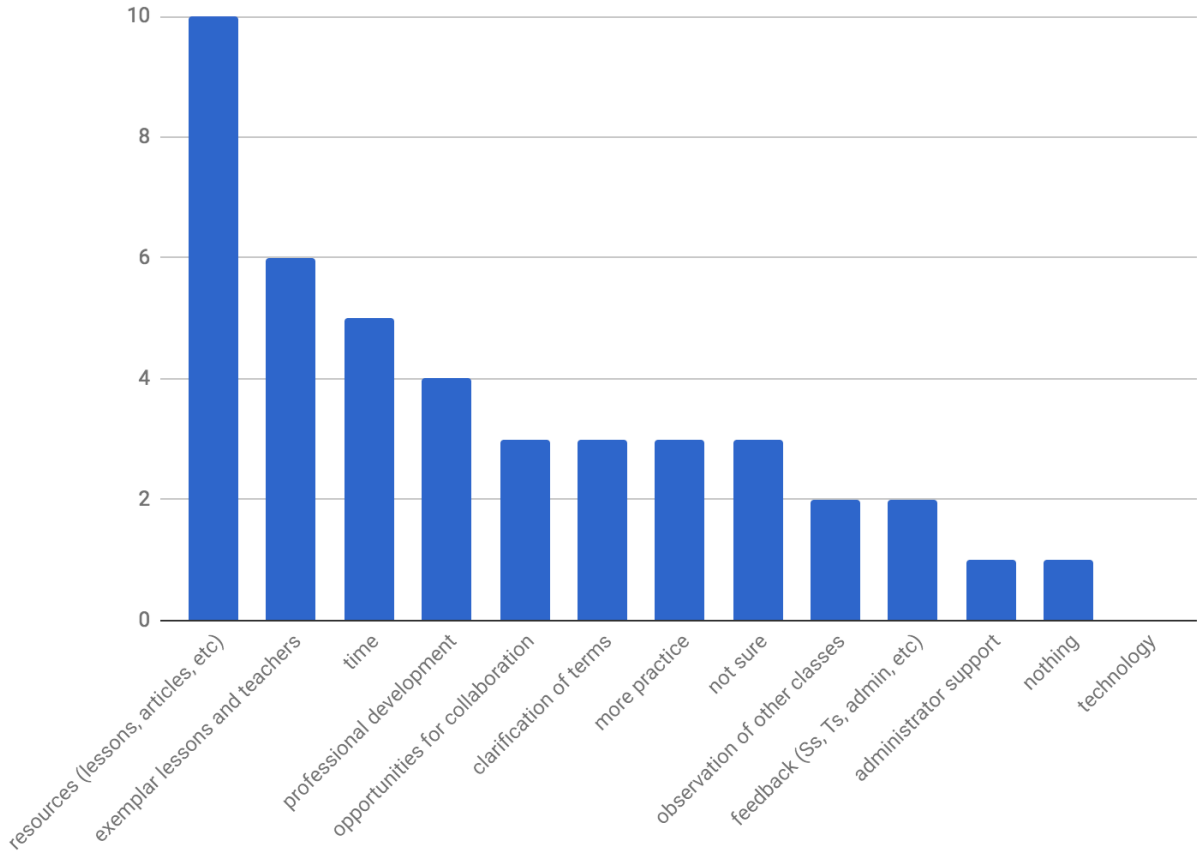

Figure 21. Group 2 questionnaire results for what is most helpful in understanding design process

The online community was presented to G2 at the beginning of the fall term when curriculum planning and networking are often at their highest. In addition to demonstrating how the community worked, the researcher added content specific to G2 interests in the classroom, in hopes of engaging greater participation. The results were like the G1 study, in that several educators created accounts and participated in a handful of interactions, but within days of the presentation, activity went dormant. Figure 22 documents the number of unique visitors to the site from the initial roll-out with Group 1 to the end of data collection with Group 2, a span of just over five months.

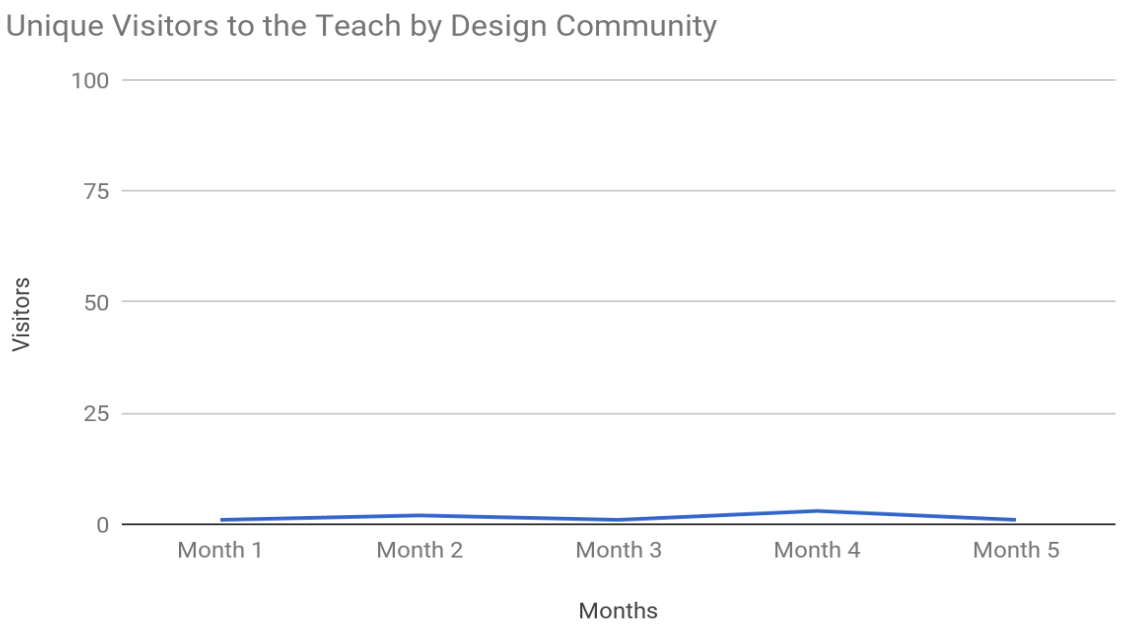

Figure 22. Unique visitors to the online community

The web analytics data collected from Groups 1 and 2 suggested that the online community was not an effective means of connecting educators interested in learning and sharing information about design thinking. In addition to this data, most participants from Group 2 also expressed the desire to collaborate either by email or face to face, as seen in Figure 23.

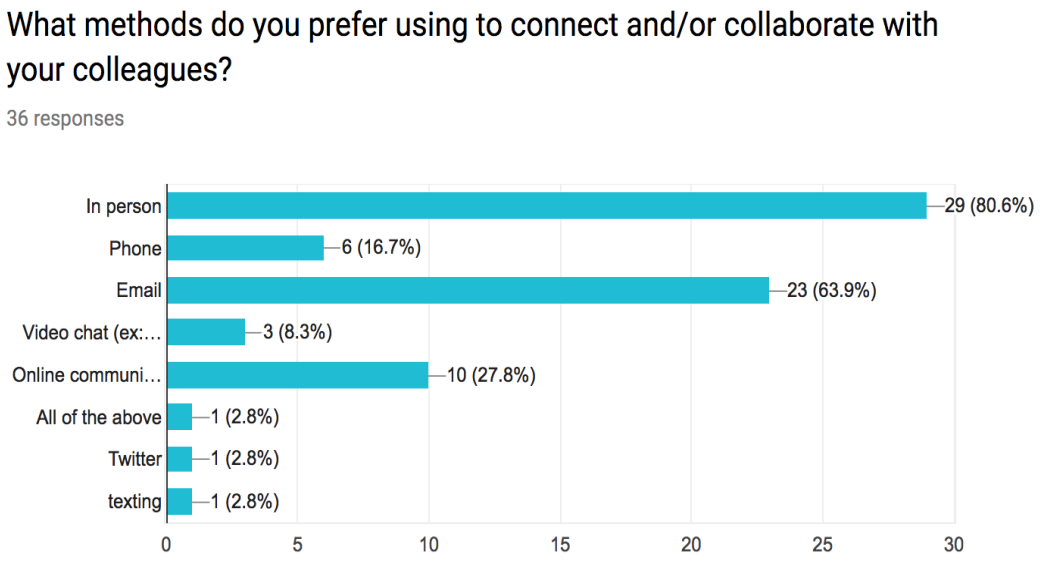

Figure 23. Group 2 questionnaire results: Preferred collaboration methods

These observations led to a third and final iteration, Cycle 3, seen in Figure 24.

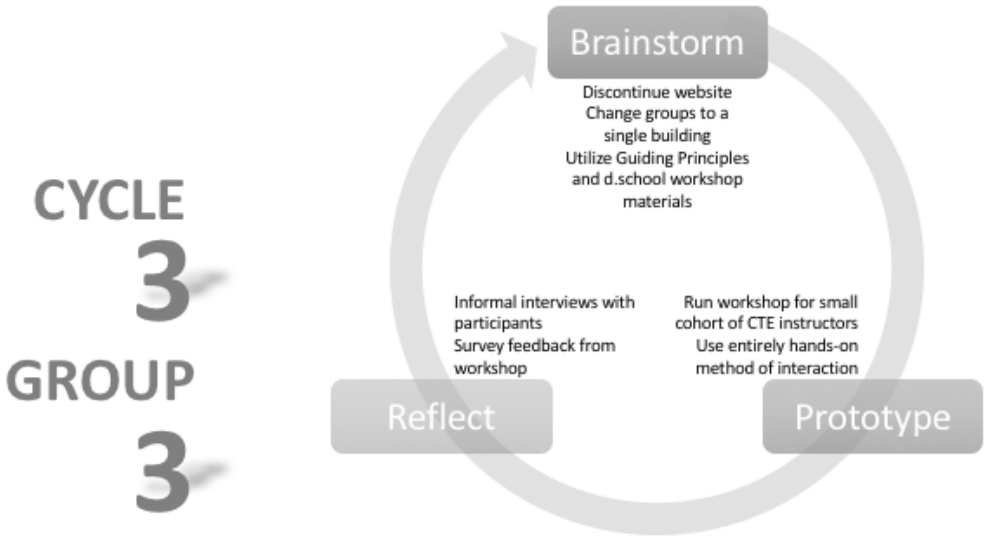

Figure 24. Implementation of Cycle 3

For the third iteration, the Teach by Design community was completely abandoned. To further investigate what conditions might produce an active community of practice based on design thinking and learning, the researcher attempted to do the opposite of an online community made up of distant, dispersed, and relatively unfamiliar participants. Instead, more localized methods of professional development were implemented, with a small cohort of interested teachers within a single building, Group 3. Recent conversations among Career and Technology Education (CTE) teachers had centered on effective and authentic assessment methods for CTE classes. With the problem already identified by this small group of teachers, the researcher along with G3 agreed to use both the design process and action research methods to develop, test, and measure possible solutions. Utilizing the methods, vocabulary, and resources provided by Stanford's d.school K12 Lab Network website as well as the Guiding Principles established in Q1, a design thinking workshop was developed based on the problem of establishing authentic methods of assessment. Engaging in the workshop itself would allow the group to solve a meaningful problem in career

and technical education, which is the first guiding principle. The researcher worked with school administrators, district curriculum directors, industry professionals, and group members to develop the agenda for the workshop (dynamic collaboration).

Following the recommendations set forth by the d.school workshop documents as well as the Guiding Principles, the workshop focused on specific parts of the design process, beginning with several ice breaker activities to allow group members an opportunity to engage in simple creativity exercises before engaging in deeper conversations. The next phase included open and honest discussions about the critical question. The conversations led to the development of the following problem statement:

> CTE courses are designed to give students real-world experiences in current technology-related fields, yet the classes are often conducted in traditional educational formats, due to a variety of factors--ex: building/district/state requirements, budget, equipment, time, etc.

From there, the group posed a critical question:

> How might CTE teachers more effectively and meaningfully instruct and evaluate students in ways that are consistent with both industry standards and district/state requirements?

Both the problem statement and critical question were intended to remain open-ended without a specific result in mind (be comfortable working with ambiguities) and maintain focus on student outcomes and experiences (user-centered).

Once the problem statement and critical question were determined, the group visited an architecture firm in the community. This firm was connected with the school district and specialized in designing educational spaces and schools for K12. The group engaged with members of the firm for an afternoon, touring their cutting-edge space design, collaborative workspaces, and inquiring about their creative processes and forms of employee evaluation. Several professionals from other design- and technology-related fields also came to speak with the group and answer questions about assessment in the workplace (dynamic collaboration).

The following day, group members gathered again to reflect on the previous day and begin brainstorming ideas for authentic assessment. Using the rules of brainstorming from the d.school workshop, the group engaged in energetic discussions, allowing all ideas, no matter how farfetched, to be considered (approach problem solving with playfulness and without judgment). Once brainstorming concluded, patterns and trends were identified and categories began to emerge. The group visited another creative firm in the area to further investigate industry practices. On the last day of the workshop, group members reflected on their findings and previous brainstorming.

What emerged from this conversation was an unexpected part of the process. While the group was able to decide on several options for assessments to be tested in the classroom (the intended target), the group also addressed several other observations they had made while visiting the design firms. Participants were greatly impacted by the visible evidence of the creative process, both on an individual and a corporate level. This included visible documents displayed at workstations, cubicles, and on a host of collaborative, writeable surfaces at both businesses, and the frequent observation of colleagues discussing and problem-solving together in a variety of flexible spaces. Figure 25 lists tangible items developed by the workshop participants, reflective of their conversations about teaching the creative process with greater intention.

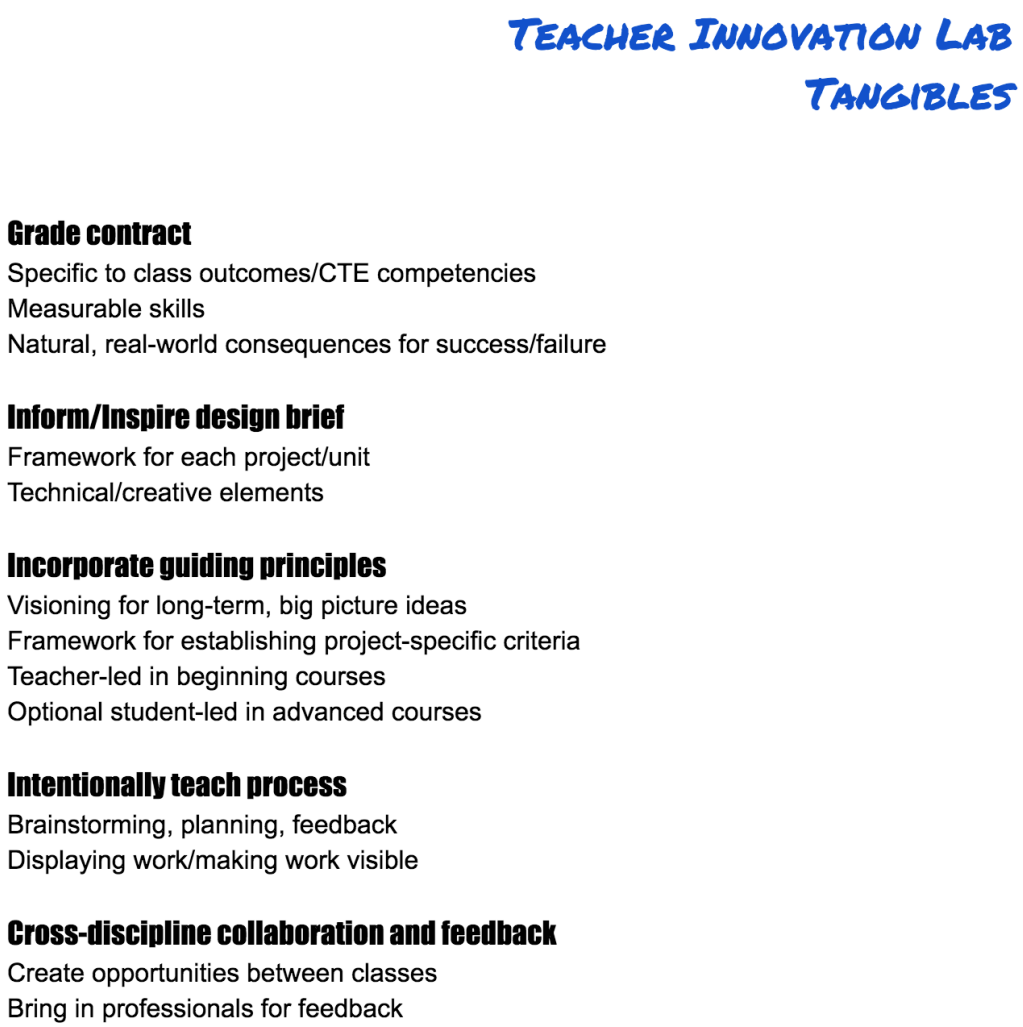

Figure 25. List of tangible items to be implemented in CTE courses

Aside from takeaways relating to employee evaluation and creative process, the group had been impacted by two other areas: collaborative spaces and guiding principles. In both design firms, the group had observed multiple areas designed for collaboration and flexibility and felt this was a critical element missing from the traditional school building. The group also spoke at length with one design firm about their use of guiding principles as a way of establishing norms, creative guidelines and constraints, and consistent design work throughout their projects and interactions. After discussing these observations, the group decided to move forward with recommendations to

the school administration for more collaborative and flexible spaces around the building. They also developed a list of guiding principles (see Figure 26) for their future collaboration with one another and within their CTE classrooms.

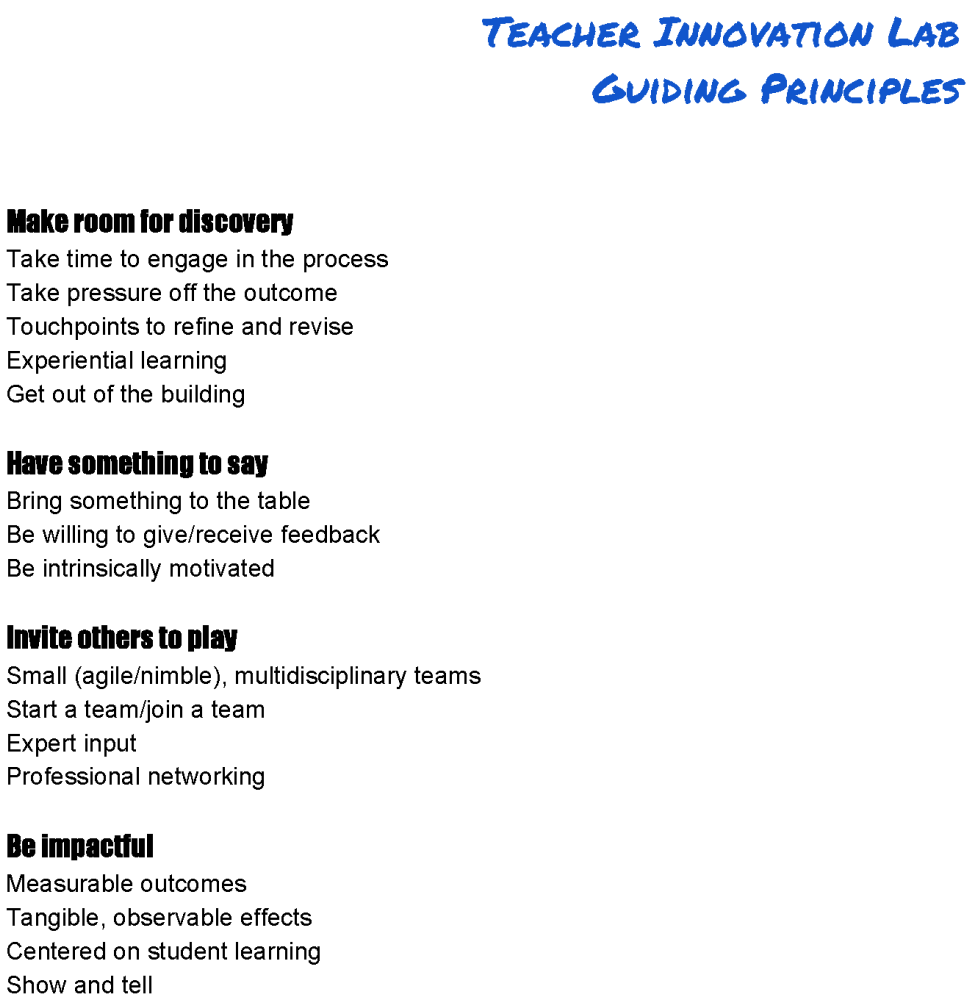

Figure 26. Teacher Innovation Lab Guiding Principles

The design process had not only allowed the team to brainstorm new solutions to the problem of assessment but the process also opened up discussions and opportunities for greater impact on the student learning experience. At the end of the workshop, the group left with new ideas for assessment, a list of tangible interventions for their classroom, and a set of guiding principles to guide their future interactions. They also made plans to meet in their own time

following implementation of the tangibles to reflect on their impact and revise as needed. The Post-Workshop Reflection Questionnaire was distributed to all six participants two months after the completion of the workshop, allowing for time to implement changes and make observations in the classroom. Four responses were collected, coded, and analyzed. The results of the first portion of the questionnaire are collected in Figure 27.

G3 Workshop EXPERIENCE: Common Themes

THEME	RESPONSES
COMMUNICATION	"I enjoyed creating a cohort of people to learn and **communicate** with" "I appreciated **communicating** with a group of like-minded teachers" "**communicating** with my colleagues was beneficial" "our **discussion** shaped the direction in which we took the experience"
COLLABORATION	"**collaboration** was the most beneficial part of the experience" "long-term, the most beneficial part was the **collaboration** effort amongst the teachers" "the most valuable part was the creation of the **group**" "my greatest takeaway is a sense of **common purpose and approach**"
REAL-WORLD EXPERIENCE	"**site visits** were definitely the most beneficial part of the workshop" "**visiting real business** and seeing how they work to be creative has really impacted how I teach" "I have benefitted from learning from people in **professional spheres**"
INTERPERSONAL EXPERIENCE	"the **people** were what attracted me to the workshop" "the **building of relationships** had a significant impact on my participation" "I appreciate now having a **sense of belonging** with teachers whose approaches are similar to mine"
LIMITED TECHNOLOGY	"I've been less likely to seek out collaborations that are mediated by **online tools**" "I'm working to **downplay technology tools** in my classroom" "**technology wasn't a factor** at all in my participation"

Figure 27. G3 Post-workshop reflection questionnaire experience themes

Questionnaire responses were positive overall about their experiences. Based on the findings, five main themes emerged from the responses. First was the theme of communication. Of the four responses, each participant described the communication among the team members as a valuable part of the experience. As one participant stated, "Our discussion shaped the direction of the experience," suggesting that in spite of the pre-planned workshop agenda, the person-to-person conversations had a significant impact on the overall experience. Though the original topic had centered on assessment, the communication amongst team members throughout the experience, and especially after the site visits, allowed more possibilities for different outcomes. Directly tied to the topic of communication was the theme of collaboration. Three of the four respondents noted that collaboration and working together as a group was a beneficial part of the workshop. While all four teachers had experience working with others in group settings, what one respondent described as a "common purpose and approach" seemed to bring this group of individuals together more so than in past collaborations.

Another key factor in making the workshop a successful one for these participants was the site visits to creative businesses and studios. The act of observing their content being applied in the real world had a significant impact on the instructors' discussions relating to content delivery in the classroom. There are countless articles about providing students with real world experiences in the classroom, but little literature suggests that teachers also need to be engaged in the real world to develop effective scenarios for the classroom. The responses from the questionnaire suggest that the real-world site visits played a major role in affecting the participants' perceptions of how they deliver content.

In addition to site visits playing an important role in the application of content in the classroom, several respondents described the interpersonal nature of the collaboration as an important factor in participation. When asked about what factors influenced participation in the

group, one respondent replied that the other individuals who planned to participate were a deciding factor; these individuals wanted to work together towards a common goal but had not been given the opportunity in the day-to-day interactions among the staff. Teachers are often separated into departments and rarely have the time or flexibility to meet with other departments, especially in a concentrated workshop such as this one.

Closely related to the theme of interpersonal relationships was the mention of limiting technology amongst the group. In contrast to the first group in this study, who had identified the use of an online network as integral to their collaboration, several respondents from the workshop identified the use of technology as a detractor to participation. It is worth noting that these comments came from participants who teach CTE courses in computer labs where technology is a key element of their course content. However, in their workshop interactions, they preferred little connection to technology, choosing to discuss and meet in person, write and sketch by hand, and visit professionals in person as opposed to meeting virtually to save time. In several instances, the researcher set up an impromptu online community using Google+ to communicate outside the workshop time frame and emailed several online resources for collaboration (a collaborative Padlet for sharing articles and ideas). Neither of these tools were used by any of the workshop members.

Collectively, these five themes demonstrate that workshop participants responded positively to interactions and experiences that were in-person, tangible, and experiential. They appreciated working in the small group and enjoyed the freedom to brainstorm and build ideas from one another's suggestions, without necessarily having a specific "to-do" list in regards to reaching pre-determined outcomes. Participants benefited from professional site visits directly and indirectly related to their content area and were energized to try new methods in the classroom. While they were able to create tools related to the original topic of assessment, they were most excited by the additional tools and ideas that spontaneously developed over the course of the workshop.

The four questionnaire respondents also reflected on the impact of the workshop on their teaching practice and student participation. Using the list of tangibles generated during the workshop, participants chose several of the items of the list to implement in their classrooms, to whatever degree they felt was compatible with their content area. Figure 28 highlights five dominant themes from their responses after implementing some of those tangible items.

G3 Workshop IMPACT: Common Themes

THEME	RESPONSES
STUDENT EMPOWERMENT	"students are **empowered** by contributing to design challenges that actually change our community and provide authenticity" "my workshop experience has enabled and **empowered** students to use their creativity to solve real problems" "design thinking makes students **empowered** to learn for the sake of their own interests and ideas"
IMPROVED TEACHING PRACTICE	"I have become a **better teacher** as a result of this experience" "the workshop experience has made me a **better teacher**"
EXPERIMENTATION/INNOVATION	"all of my ideas now focus on **design thinking**" "the workshop has made me much more **innovative**" "students are **trying out more things** and feel more comfortable **taking risks**"
CREATIVE PROCESS	"I've become more open with my students about my own **process**, and I have been encouraged to engage in more **process-based conversations** in my class" "the workshop gave me a framework to better implement the **creative process** with students" "seeing creative professionals really impacted how I **teach being creative**" "the collaboration has immensely impacted my **brainstorming activities** and procedures in my classroom"
STUDENT-CENTERED	"I still have traditional lessons, but the workshop has made me much more **student-driven**" "the experience got me interested in researching and implementing design thinking and **student-centered** learning into my classes" "I have been reminded and encouraged to **keep the student at the center** of everything we do"

Figure 28. G3 Post-workshop reflection questionnaire impact themes

The two greatest areas of impact amongst the responses included student empowerment and improved teaching practice. Three questionnaire respondents described students as being highly engaged in activities that involved the design process and solving real-world problems. Additionally, three questionnaire respondents said that the workshop experience "made [them] a better teacher," as evidenced in the student response to their design process-based lessons. In all three circumstances, the instructors created lessons that incorporated the design process and invited students to identify and develop solutions for problems they faced in their own school environments. In one instance, students gave input to administrators about redesigning spaces around the school, and administrators gave them permission to actively change those spaces. In another instance, students presented to teachers their research and proposed solutions for reducing "busy-work," work they defined as having a direct impact on their grades but little to no relation to course content (e.g., extra credit points for supplying boxes of tissue for the classroom). In both examples, the workshop participants noted that creating and implementing lessons because of the design workshop both empowered students to have an active role in their school community and gave the instructors a greater sense of engagement and accomplishment in their teaching practice.

During the workshop, participants had observed and spent time discussing practical applications and teachings of the creative process. This topic was incorporated into both the List of Tangibles and Guiding Principles created by the team. Not surprisingly, the focus on creative process both as a teacher and as a student was a prominent theme in the overall impact of the workshop on participants. Overall, participants felt more comfortable thinking about, engaging in, and communicating with students about the creative process, resulting in a greater student awareness of how they create, revise, and present their final products.

Closely tied to the theme of creative process was a reported increase in experimentation and innovation, again both on the part of workshop participants and student outcomes. As participants were more cognizant of their creative process, they opened up to taking more risks in

the classroom, trying out new ideas, and coming up with creative ways to introduce material to students, especially in the form of design challenges that did not necessarily have a pre-determined outcome. This contrasts with more traditional methods of teaching where the content delivery is often directly tied to the final unit exam or assessment. The increased ability of workshop participants to take risks and try new things was modeled by the instructors and passed along to students, as observed by "students trying out more things and feel[ing] more comfortable taking risks."

Last, questionnaire respondents observed that their teaching practice became more student-centered because of participating in the design workshop. Empathy is the first step in the design process, and it encourages participants to consider the perspectives of others. This was demonstrated in the design workshop by discussing observations of and feedback from students in CTE classes as well as the site visits that allowed participants to see what professional experiences will look like for students in their courses. As mentioned before, the site visits were eye-opening for the participants, since they do not often have the opportunity to see their classroom content actively demonstrated in the real world. This step in gaining empathy for student experiences and future careers gave the participants a different perspective on the ways in which they deliver course content. The site visits gave them a greater opportunity to create relevant, industry-based experiences in CTE courses, specifically for providing students with realistic procedures, processes, and assessments that they could expect to face in creative professions.

The Post-Workshop Experience Questionnaire also asked respondents to share their thoughts on what they considered best methods of instructing colleagues in the design process, based on both their experience in the workshop as well as past professional learning experiences. Figure 29 illustrates their responses.

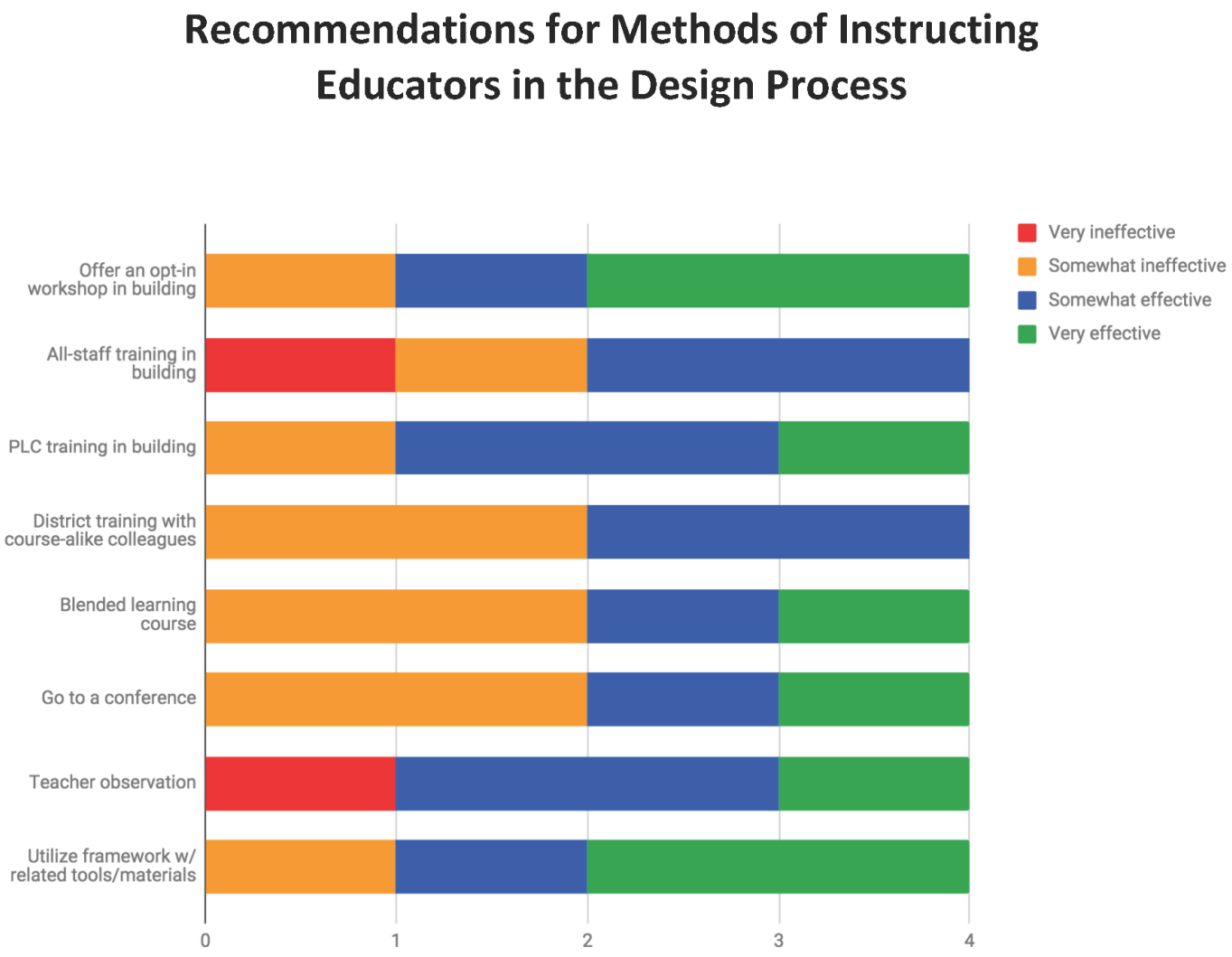

Figure 29. Recommendations for methods of instructing educators

The responses suggest that the methods for greatest effectiveness included a workshop where participants could opt-in and choose to be part of a workshop. The other category that ranked highest in effectiveness was providing instructors with a framework and easy-to-use tools to implement the design process. Several toolkits exist for this purpose, including IDEO's Design Thinking for Educators Toolkit and the Stanford d.school's Bootcamp Bootleg. However, while these toolkits do provide educators a framework and resources for teaching design thinking to students, they are not specifically designed for teacher professional development. That is, the

resources do not provide a framework for administrators, district representatives, and professional learning coordinators to instruct educators on the design process. Interestingly, workshop participants felt that all-staff training in the design process was the least effective method for sharing design thinking among colleagues. Responses were fairly divided in the remaining categories.

A few months after the questionnaire was distributed, workshop participants met in person to reflect on their experience overall. Taken from notes and transcribed recordings, all members reported having used the new techniques in class, with varying degrees of implementation and success. In an interview with one of the group participants, the instructor described this experience:

> One of the greatest success stories included a class experiment where I engaged the students in the design process to imagine how the school might be improved with more collaboration space, as we had experienced in the design firms. The students used the design process to research (including visiting the same design firms and working with architects to develop plans), brainstorm, and propose potential ideas to the administration, and their ideas were approved. The administration purchased an entire hallway of white boards, and the students wrote and received a $3000 grant to renovate an underutilized portion of that same hallway to generate a more flexible and usable space. The students then did the hard work of cleaning, painting, and hosting an open house to invite the student body to the newly designed space. –Workshop Participant

When asked about the impetus for this redesign project, the participant credited the group's design workshop experience as being the inspiration and confidence for trying the design process in class.

Though multiple circumstances and conditions account for the dichotomous results of the widely-dispersed online community and the small cohort of colleagues, these three iterations of

implementing the spread of design thinking amongst K12 educators suggest that small cohorts of teachers working through the design process have a greater chance of leading to positive results. One possibility for the success of G3 could be that engaging in the design process inherently requires active, synchronous participation and collaboration. To best learn about the design process, it should be experienced first-hand, in the company of others going through the same experience. The physical acts of observing others in their environment, brainstorming on white boards, and sketching and making with collaborators for immediate feedback, are all hallmarks of the design process, and lead to the most effective outcomes. This research would suggest that for the purposes of learning and sharing knowledge about design thinking specifically, participants should be physically present with one another and actively involved in working through the design process together. The spontaneous interactions that result from in-person conversations, experiences, and idea generation cannot be suitably replicated in an online forum.

RQ3: How might educators best prepare for implementing design thinking in the 21st century classroom?

The previous two research questions addressed the Plan, Act, and Observe phases of the action research process, as well as the Research, Define, Brainstorm, and Prototype phases of the design process. This final question will address the Reflect phases of both processes, reflecting on the three cycles of the design process and the lessons learned from each iteration. To summarize the results from RQ2, the cycles and observations showed that an online network was ineffective in engaging Group 1 to collaborate virtually, even when they had expressed a specific desire to do so. Group 2, though they had established professional relationships with one another and with the researcher, chose not to engage in the virtual collaboration and online community tool, citing that they either did not have time to participate in additional online communities or preferred to collaborate and share resources face-to-face or by email. Group 3, when given the time and opportunity to actively engage in a design process workshop based on a problem relevant to their

classroom, participated enthusiastically and have not only continued to use the design process in their classrooms but also have used the process in new and innovative ways, shared the process with other educators, and expressed positive attitudes about using the design process.

Because of these findings, analysis of the data collected from this research study indicates that participants were more likely to implement and share design thinking among K12 educators not through an online community (despite its global accessibility) but rather from an interactive, personal, and relevant workshop experience. Data collected from the third cycle showed that participants were most interested in learning the design process when given the choice to participate in small groups (as opposed to obligatory participation). Participants also expressed a desire in utilizing a framework to make implementation more effective and consistent. Thus, the final prototype of this research study has not resulted in the development of a successful online community as was hoped for at the outset of the study, but instead it has resulted in a framework for implementing the use of the design process and design thinking activities at a local level, even within individual buildings. The views shared by Group 3 participants in the design workshop aligns with the research of Lave and Wenger (1991), where the "learners" in this group participated in the design process, moving towards full participation and sharing their new knowledge with others, who in turn have learned about using and implementing design thinking. The research would suggest a successful community of practice has been formed through the third iteration of this design process.

Data analysis for RQ3 draws heavily from the third iteration and its findings, as it demonstrated the greatest impact on the teaching practice of the participants. Based on the data collected from Group 3 workshop participants' experiences, impact, and suggestions for implementation, five essential criteria were established to develop a framework, called Teacher Innovation Studio, for implementation: building-level opt-in workshops, small groups of four to six individuals, focus on empathy, observation of real-world practices and content application, and

time for experimentation, reflection, and revision. In addition to these criteria, the Guiding Principles established in RQ1 were also included in the framework, as several principles overlap with the criteria developed from RQ2 (see Figure 30).

GUIDING PRINCIPLES FOR TEACHING DESIGN THINKING	CRITERIA FOR DESIGN THINKING FRAMEWORK
1. Identify and solve relevant, meaningful problems in the real world, not the school world	-Observation of real-world practices and content application
2. Collaborate dynamically and frequently with colleagues and professionals outside the field to get the most out of everyone's collective knowledge	-Building-level opt-in workshops -Small groups of 4-6 individuals
3. Develop a laser-like focus on the needs and perspectives of others (this includes students)	-Focus on empathy
4. Engage in the physical acts of making, sketching, and media creation for quick, iterative visualization and feedback	
5. Experiment, revise, refine... repeat!	-Time for experimentation, reflection, and revision
6. Be willing to act flexibly and work in places of unknowns and ambiguities	
7. Approach problem solving and brainstorming with playfulness and without judgment in order to increase creativity and innovation	

Figure 30. Guiding principles and framework criteria compared

The framework was titled Teacher Innovation Studio because it evokes imagery of a space where creativity and constructing occur, activities require exploration and novel thinking, and the work empowers teachers to be the source of new ideas in education. The studio also refers to multiple documents from RQ1, alluding to Dewey's model of experiential learning and Schon's design studio, for the Teacher Innovation Studio would be housed within a school and could be

piloted at a single location or broadened to an entire district or region. The model would be scalable depending on the needs of each individual community. As illustrated in Figure 31, the framework utilizes the same action research and design process methods used in this research study, to mirror the methods used in RQ2 as well as ensure that educators have time to implement solutions, collect data, and make revisions.

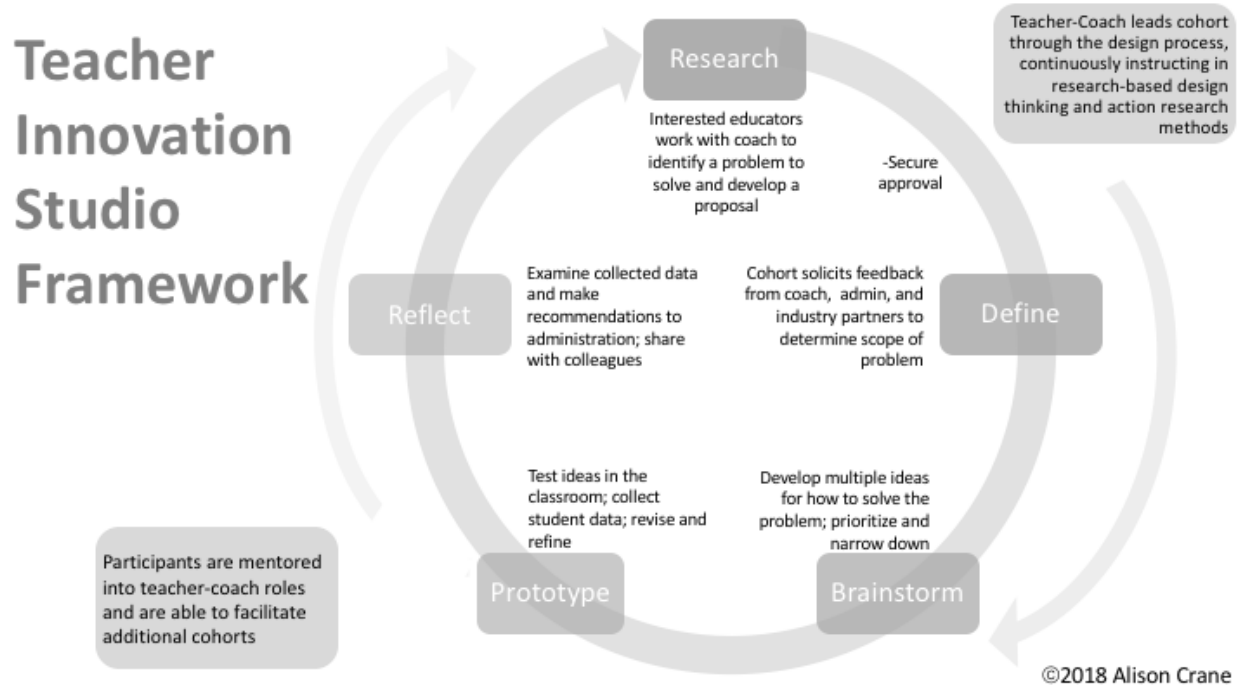

Figure 31. Teacher Innovation Studio Framework Diagram

The Teacher Innovation Studio Framework Overview

Utilizing Lave and Wenger's (1991) model of cognitive apprenticeship, an expert in the field of design thinking would guide a small cohort of teachers through the Teacher Innovation Studio Framework to solve a relevant problem in education. This expert could be a fellow lead teacher, an instructional coach, or even a professional well versed in methods of design thinking and design process. Cohort teachers would be identified for the Teacher Innovation Studio either by application or recommendation (demonstrated interest and/or disposition), and then apply for

participation in a design thinking cohort (length of time would be determined by the problem to solve). Similar to creating a proposal for an action research study or design brief, the application process would include a proposal identifying the problem to solve, potential collaborators, necessary resources, and a suggested timeline. Applications would be reviewed by the teacher-coach, building administrators, as well as appropriate district representatives for approval (including allocating time away from the classroom and any funding needed for implementation of the process).

Teachers who successfully participate in the cohort would be identified as professional development leaders in their schools and have the skills and knowledge to provide leadership to their colleagues, both at a building and district level, thereby expanding the community of practice.

Depending on district structure and availability, a program coordinator should be identified to act as a liaison between the cohort, administration, and district representatives. The coordinator could be the cohort leader, a building staff member or administrator, district representative (such as a curriculum director or instructional coach), or a new position developed to help expand the framework. The Guiding Principles for teaching design thinking should be introduced at the beginning of each cohort and used as a guideline for norms prior to engaging in any workshop activities.

TISF Process

The TISF process utilizes best practices in action research, design process and problem solving to develop innovative solutions for K12 education. Workshops would begin either at the beginning or end of a school term (taking advantage of more flexible out-of-class time as well as longer periods of reflection and preparation), and include various touch points throughout the school year to reflect, refine, and share results. Relevant industry partners will be invited to connect throughout the process to provide valuable 21st century career readiness input.

Proposal for Pilot Program

Before implementing at a large scale (as many educational processes and reforms are), one or several schools should prototype the TIS framework at a small scale to establish baselines and gather results. Just as the design process requires prototyping, testing, and revising, the TISF should be given a period of testing to determine how it best fits in a particular school or district before reaching full implementation.

The pilot session would begin with a multi-day workshop, where teachers would collaborate to examine a problem of relevance and importance in their community. Utilizing action research and IDEO's design process methods, the pilot group would engage in team-building activities, educational research, brainstorming sessions, prototyping, and meetings with community partners to develop potential solutions to their identified problem.

At specified touch points throughout the year, the pilot group should convene again to review the findings. They will also determine criteria for revising, implementing and assessing the effectiveness of these findings. Throughout the semester, pilot teachers will collect data both on student response to and effectiveness of their experiences. The group would meet at the end of the term to review data, refine the experience and implementations as needed, and share their results with fellow colleagues and the program coordinator.

Program Evaluation

Just as the teachers will be participating in action research to improve their teaching, the Teacher Innovation Studio program coordinator should conduct action research to determine the effectiveness of the program. At the end of the first pilot program cycle, teachers will be surveyed about their experience in the program. Student data will also be collected, including feedback about their learning experience in the classroom. Other measures will be included to determine overall effectiveness and inform decisions about future TIS experiences.

As evidenced in the Teacher Innovation Studio Framework above, the process relies on the following components: adherence to the previously established Guiding Principles and standard methods of the design process in order to effectively research, brainstorm, and prototype possible solutions; adherence to action research methodology in order to implement, learn from, and improve tested methods; and adherence to theories of communities of practice and legitimate peripheral participation in order to identify, mentor, and develop into leadership positions teachers who can successfully share knowledge of and implement design thinking with their colleagues and in their classrooms. Based on the data collected from both RQ1 and RQ2, this framework could serve as one possible solution to the question posed in RQ3.

CHAPTER 5

DISCUSSION

Introduction

This chapter includes a comprehensive overview of the entire study and is divided into the following sections: a short summary of the study objectives as well as the analysis, discussion of the findings, limitations of the study, implications for practice, future research, and conclusion.

Summary

In the last five years, design thinking has become a prevalent model for innovation in some of the world's top organizations, with the creative firm IDEO leading the way, both in setting industry standards for design thinking processes and working with educational partners to influence kindergarten through higher education. However, while teachers and schools have been encouraged to use design thinking and design processes in their classrooms, only in few instances have teachers been given any formal training in how to execute these methods. In addition, teaching students to use the design process to gain content knowledge looks different from what was expected of teachers during the NCLB era, and education is moving slowly to make changes that would allow teachers the time, training, and allowances necessary to accommodate this pedagogical change.

The purpose of this study was to discover effective methods for developing and sustaining communities of educators to learn about, share knowledge, and implement design thinking in K12 classrooms. This study drew heavily from Lave and Wenger's (1998) work on communities of practice as well as IDEO's development and implementation of design thinking and design process. To that end, the following three research questions were established:

1. What core guiding principles of design thinking are most important, relevant, and feasible in K12 education?

2. What are the best methods for K12 educators to learn and share knowledge about teaching design thinking?

3. How might educators best prepare for implementing design thinking in the 21st century classroom?

In addition to the literature on communities of practice, this research also relied upon theories of situated cognition, 21st century skills in K12 education, teacher engagement in online communities, and principles of the design process and design thinking. The literature suggests that design thinking is a valid tool for practicing and improving 21st century skills such as critical thinking, problem solving, and collaboration. Utilizing theories of communities of practice would suggest a promising way of teaching educators how to implement design thinking in their own practice and as a tool for students to grow in 21st century skills. However, not all communities of practice are created equal; for instance, research on online communities of practice shows that they are not as successful as either blended or purely physical communities. With the rise of personalized learning, blended learning, and its applications to teacher professional development, this research suggests that when it comes to design thinking, these methods may not be as successful in initial implementation.

Discussion of the Findings

Through the action research process, several important principles were established. To begin with, the process of analyzing and creating guiding principles that were tied together by industry standards, K12 education standards, and theoretical relationships was valuable in discovering the most important elements of what K12 design thinking training should encompass. Design thinking by its nature is a hands-on process and works best when participants can engage in face-to-face collaboration. Though it was not necessarily a mistake or incorrect assumption, as the first group of participants had specifically asked for an asynchronous digital community, the decision to create an online community indicated that virtual communities are difficult to establish,

especially under the conditions in which this community was created. They were less than ideal, as suggested by previous research of successful online communities.

However, this research did not necessarily prove that online communities can only succeed under ideal conditions. Rather, it suggested that the topic of design thinking was not the best topic for conducting research on online communities. Because of the hands-on, collaborative nature of the design thinking process, the network was never the best solution for connecting educators to learn more about how to engage in design thinking. Even though users thought they wanted a specific tool, it was not the best tool for the job or the best solution for the problem. Had the first round of the design process started more like the third round, where participants had less defined expectations for a specific final product, the initial group might have had a more successful collaboration. Even with the application of the guiding principles to the online community, there were several incorrect assumptions made about how those principles could be effective in a virtual environment. What resulted from this study is that online communities are not ideal for the specific task of learning, sharing, and implementing content related to design thinking.

Online communities of practice such as the Adobe Education Exchange, the Scratch community, and even Autodesk's internal communities have large buy-in and participation, but as noted in the network audit, these online communities are directly or closely tied to large industries or institutions. Those communities developed by local groups or even individual educators were much harder to sustain. Chiu et al. (2006) concluded that the hardest part of establishing and sustaining an online community is knowledge sharing. In observing the interactions of the third group, the success came from not only sharing knowledge but from the creation of new knowledge. It was in the moments of discovering, brainstorming, and reflecting on their attempts that the team learned the most about the impact of design thinking on their teaching and profession and shared ideas with others. This observation might suggest that the knowledge-creation aspect of design thinking is what was most challenging to facilitate with the online community. That is, not

having access to the interpersonal interactions that result in spontaneous new ideas and solutions is a limiting factor in an online community.

Another key observation from both the second and third groups was a lack of interest in using technology for school purposes. When the study was initially started, tools like Google Classroom, one-to-one district policies, and social media-based professional learning networks were still in more experimental phases; however, as technology use has become more ubiquitous, cloud-based, and susceptible to data and privacy concerns, teacher attitudes may have shifted. While participants in the second group identified a lack of time and interest for using technology to collaborate professionally, participants in the third group identified a need to reduce technology use for students in the classroom; this observation from the third group is puzzling considering the curriculum falls within the Career and Technical Education strand for secondary students. A possible explanation for these attitudes can be found in Turkle's *Alone Together*. Turkle (2017) describes the irony of the connected life making humans feel even less connected, illustrated by a story of a woman who uses Skype to converse more frequently with her grandmother, only to find that she spends her time on Skype multitasking, paying even less attention to her relative (p.14). Having seen the widespread use of mobile devices and the resulting disconnectedness among young people and experiencing it themselves, educators might not be enthusiastic about using technology for every classroom experience. The strong desire from the third group to limit technology use for collaboration and engage fully, synchronously, and in person suggests that educators still value that personal connection and want to impart that engagement to their students. The design process provides a natural vehicle for teaching educators and students to be present with and considerate of one another.

While the data collected and conclusions drawn suggest that online communities of practice were not a successful method of sharing knowledge about the design process, the success of the third community as well as the development of a potential framework suggests that the

design process itself proved successful. By continuing to iterate and prototype possible solutions, gathering data from users, and revising and refining methods, the third iteration of the cycle provided the best solution for that particular group of participants. In that particular iteration, the results showed that the best methods for teaching teachers to learn about design thinking is to utilize a modified form of legitimate peripheral participation: begin the process with expert facilitators leading in small groups to solve a relevant and meaningful problem, and as the facilitators help guide teams through the process of solving a specific problem, teach how to utilize the process to solve problems in general, thus creating groups of future facilitators in design thinking and processes. In order to determine if this is the best solution for a broader audience, more testing would have to be done, including attempting the framework in a variety of educational contexts, content areas, demographics, grade levels, etc. As both the primary researcher and an educator involved in implementing these methods in my classroom, this study attests to the design thinking principle that failing often leads to greater learning and success.

Limitations of the Study

Several limitations with this study prevented it from being repeatable, universally applicable, or without flaw. To begin with, the decision to use action research and work within a small, narrowly defined community of educators means this research is not necessarily transferable to educators in other content areas.

The lack of use of the prototyped online community was unexpected and therefore resulted in the absence of web analytics data, which had been intended to provide the bulk of quantitative data.

Due to the nature of the action research study, purposive sampling was used, which can produce biased results. Also, the samples were small, which reduces the ability to generalize results to larger populations.

Communication with the first group proved to be one of the most challenging and limiting aspects of the study. Because the first group did not already have solid connections and relationships either physically or virtually, it became increasingly difficult for the researcher to maintain communications with some of the individuals, especially as the group membership ebbed and flowed. This discontinuity was unexpected and therefore caused limitations in drawing and sustaining membership to the virtual community.

Implications for Practice

Ultimately, how do these findings impact teacher practice in learning how to implement design thinking in the classroom? The first question to consider is this: does design thinking have to be taught face-to-face? IDEO has collaborated with various partners to create online tools for learning design thinking, including Stanford d.school's Virtual Crash Course, IDEO U's Hello Design Thinking course, and +Acumen's Introduction to Human Centered Design, which all offer virtual courses for sharing design thinking methods, but they also require collaborators onsite to practice those methods. As schools and districts move towards utilizing personalized professional development, facilitated by the use of online learning modules, they should be aware that design thinking is not a concept that should be introduced in this manner. For applications in education, this research suggests that best practices for sharing design thinking is done in person or in small groups with an expert facilitator. Once participants have become practiced in and feel comfortable using the methods, online tools for collaboration can help facilitate their communication, but initial introductions and trainings should not be conducted virtually.

The Teacher Innovation Studio Framework also provides a potential gateway into new professional communities in education. For the last two decades, one of the more popular forms of professional learning in education involves the professional learning community, developed by DuFour and Eaker (1998). DuFour (2004) claims the three big ideas of professional learning communities are ensuring students learn, collaboration, and focus on results (DuFour, 2004).

While ensuring students learn should be all educators' top priority, the results DuFour (2004) describes are measured through means of developing common, standardized assessments across teams of students and teachers, which are ideal for producing the results outlined by NCLB. In the 21st century, however, as national standards and education reforms seek to address critical thinking, problem solving, and authentic learning environments, standardized tests and common assessments are no longer the only acceptable way to measure student learning.

What if, instead of professional learning communities focusing on academic achievement as measured by scores on a test, teacher communities focused their collaborative efforts on 21st century skills, shifting to professional problem-solving communities? What if these communities were trained in design thinking methods to solve problems related to teaching and learning? Social media was not even invented when PLCs became the model for teacher professional development; now, teachers and students have access to extensive social media, professional learning networks, free online courses, and tutorials in a vast array of subject matters from highly regarded accredited universities and professional organizations with more data than could have been imagined 20 years ago. As content becomes increasingly cross-disciplinary, the silos of traditional subject matter-themed communities become less effective. Communities could be organized by problems to solve rather than content area. The Teacher Innovation Studio Framework could serve as a method of identifying meaningful problems to solve and arranging educators into cohorts based on a specific problem. The collaboration of professional learning communities is necessary, but to elevate the conversation, creating cross-collaborative learning communities would bring different voices to the table. Utilizing the theory of legitimate peripheral participation, if teachers collaborated on several cross-disciplinary teams, they might be able to exponentially increase their knowledge base.

Future Research

Research from this study as well as other studies show that there is still room to examine long-term effects of design thinking both on students and educators. The method has only been

recently adopted in the field of education and should be observed over the course of several years of student data to show what effects design thinking has on students.

This research has also shown shortcomings in the use of educational technology in helping to facilitate the learning and sharing of knowledge related to design thinking in K12 education. Few networks exist to connect educators on this seemingly important and relevant topic.

The research of Koh et al. (2015) has done much to establish the use of design thinking in education in Singapore. Based on the observations from the work of Koh et al. (2015), additional work needs to be done in terms of giving pre-service teachers experience in using design thinking both as a tool to design their own lessons and as a method for student interactions. Additionally, more research should be done to examine how to train in-service teachers to develop design dispositions as one of the tasks they are required to do.

Last, further tests need to be conducted in a variety of situations to examine the effectiveness of this study across multiple content areas and educational environments. For example, the framework could be introduced and examined across multiple content areas, grade levels, and teacher experience levels to determine the impact of design thinking on teacher satisfaction and innovation in the classroom, as well as student performance related to 21st century skills. Measures could include teacher attitude surveys both before and after the implementation of design thinking, and student performance assessments related to creativity, critical thinking, collaboration, and communication.

Conclusion

The research gathered from this study has contributed to the literature on design thinking in K12 in multiple ways. First, this research has shown, albeit in limited scale, that the use of design thinking in education has had a positive impact on both students and educators. The ability to use the design thinking process for solving any type of problem helps to develop problem solving skills, creativity, empathy, and metacognition (Soleas, 2015). The key, however, is in learning how

to teach and implement the process correctly. Too many professional development research studies show that methods for training teachers in new content are uninspiring, lack longevity, are unsupported after the initial training, and leave teachers feeling more overwhelmed than before (Cuban, 1986; Dede et al., 2009). For design thinking to have the same results that are being seen in industry (Kolko, 2015), the process must be introduced, taught, implemented, and supported by administrators and staff alike.

This study also showed that a small group of educators expressed positive attitudes towards the design process after completing the workshop. They felt more comfortable in understanding and explaining design thinking. They observed positive student engagement and empowerment. They expressed common sentiments regarding the desire to communicate and collaborate in person, and engage with industry and professionals outside of the school environment. And surprisingly, they conveyed a common interest in stepping back from technology. As teachers around the country are being expected to educate digital natives, the demand to be flexible, creative, innovative, empowering, and engaging is only going to increase. Design thinking can have a positive impact on K12 education, especially for teachers as they continually reflect upon and revise their teaching methods. The design process as a methodology makes sense for "the reflective practitioner," as professionals view their roles more as designer and less as content disseminator. Additionally, engaging in the design process and utilizing design thinking builds creative confidence to try new things (Jobst et al, 2012). Creativity leads to innovation in organizations as well (Amabile, 1988, p. 126). This research project has cemented the idea that pursuing widespread adoption of design thinking in K12 education can yield positive results for both students and educators.

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